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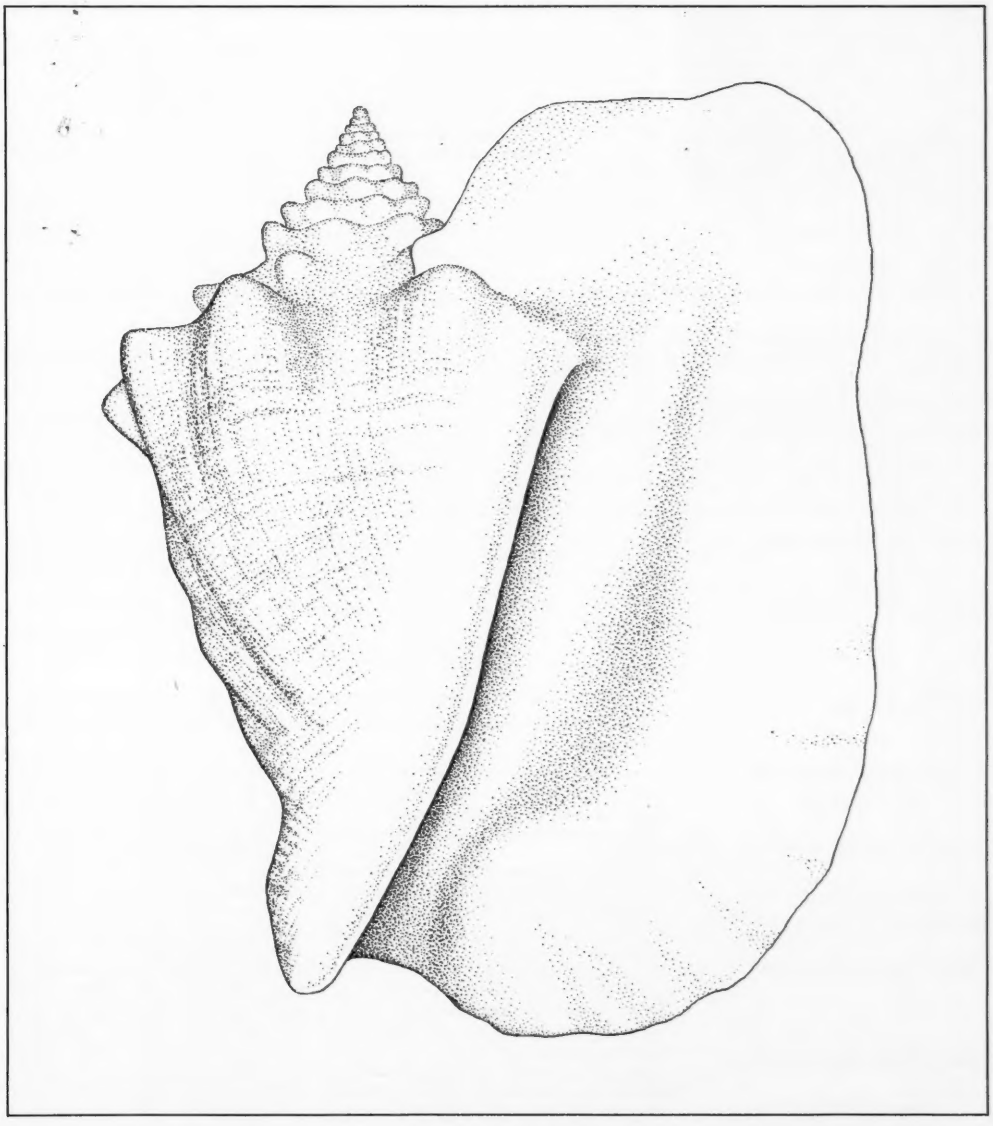

The Queen Conch

Marine Fisheries REVIEW

On the cover: The queen conch, *Strombus gigas*. Illustration by Harold L. Spiess.

Articles — *July 1981, 43(7)*

The Biology, Fisheries, and Management of the Queen Conch, *Strombus gigas* — *Willard N. Brownell* and *John M. Stevely* — 1

Habitat and Nursery Grounds of Pacific Rockfish, *Sebastes* spp., in Rocky Coastal Areas of Southeastern Alaska — *H. Richard Carlson* and *Richard R. Straty* — 13

Conditional Fishery Status as a Solution to Overcapitalization in the Gulf of Mexico Shrimp Fishery — *Vito Blomo* — 20

Departments

NOAA/NMFS Developments — *U.S. 1980 Fish Exports, Albacore Landings, Marine Anglers,* and *Sea Turtle Protection* — 25

Foreign Fishery Developments — *Peru's Fisheries, New Zealand Fisheries, Pakistan Fish Rules, Caribbean Pollution,* and *Japan: Billfish, Surimi, and 1980 Imports* — 27

Publications — *Pacific Salmonid Ecosystems, Limited Entry, Tuna Fishing, Fish Phenology,* and *Fishes of New York and Idaho* — 31

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The Biology, Fisheries, and Management of the Queen Conch, *Strombus gigas*

WILLARD N. BROWNELL and JOHN M. STEVELY

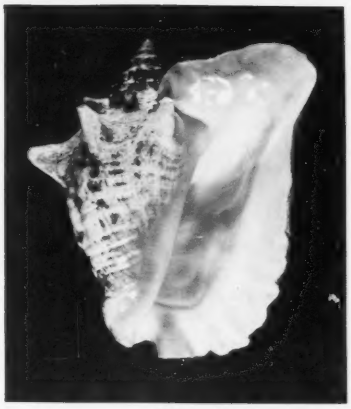

Figure 1.—Adult queen conch, *Strombus gigas*.

Introduction

The queen conch, *Strombus gigas* (Fig. 1), a large marine snail, has been a principal source of food for the inhabitants of Caribbean coasts and islands since the first American Indians settled there long ago. Today it remains an important source of protein in the region, while imports by the United States have grown. However, stock depletion is now occurring in many areas due to overfishing.

This particular conch is one of six species of the family Strombidae found in the Caribbean and Florida, and is by far the region's most important mollusk. Queen conchs are heavily fished throughout most of their range from Bermuda and southern Florida, all around the Caribbean, south to Cayenne (Fig. 2). Besides conch (pronounced "konk"), they are also known as botuto (Venezuela), cambombia (Panama), carrucho (Puerto Rico), cobo (Cuba), guarura (Los Roques), lambie (Windward Islands), and lambí (Hispaniola). They are also frequently called "pink conch."

In some places, such as the Caicos Bank, conchs with thick, stubby shells and leathery black skin are found. These are called "samba" or "sanga" conchs. Fishermen consider them to be a different, and far less desirable, animal, while biologists say they are simply a morphological variation of the queen conch (Randall, 1964).

Economically, the queen conch is now the second most valuable Caribbean fishery resource after the spiny lobster. As a protein resource it has been second only to finfish in native diets for at least 100 years. In addition

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ABSTRACT—Available information on the biology, fisheries, and culture of the queen conch, Strombus gigas, *throughout its geographic range, is reviewed. Beginning in the early 1970's, development of a lucrative frozen conch meat market in the United States dramatically increased the economic significance of the queen conch. However, the current condition of several conch fisheries indicates that these stocks are insufficient to meet demand. Some conservation measures have been implemented, but lack of fisheries biology data and fisheries personnel hamper development of comprehensive management plans. Problems with stock depletion have focused attention on the possibility of conch culture and/or stocking. In recent years a number of small, local research projects have been initiated to study queen conch biology and larval rearing. However, expanded research is needed to develop larval culture techniques applicable to pilot scale hatchery operation.*

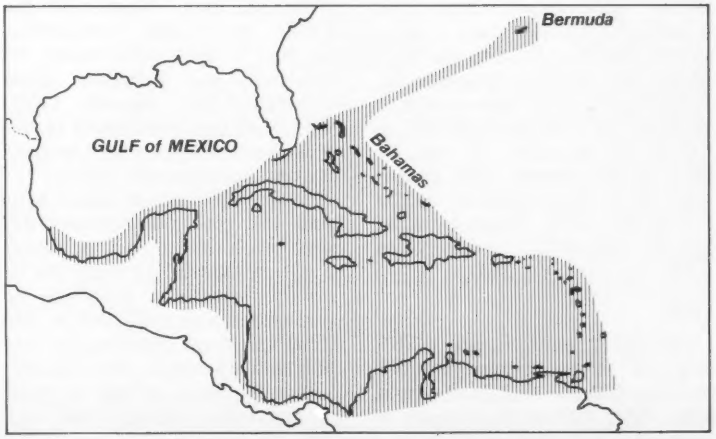

Figure 2.—Geographic distribution of queen conch, *Strombus gigas* (after Warmke and Abbott, 1961).

to the value of the meat, the brightly colored shell is often sold for ornamental purposes and was once used in the manufacture of lime and porcelain. Occasionally, an irritating particle lodged between animal and shell results in production of a conch pearl. Although these pearls often have high market value, demand for them is limited since they fade with age.

Today, rapidly expanding human populations throughout the region have brought more modern fishing methods, more sophisticated processing and marketing structures, and the queen conch has been overfished over most of its range. Catches in most areas now are not even sufficient to satisfy local demand, much less to take advantage of lucrative export markets. This paper reviews the biology and fisheries of the queen conch and also considers management and research strategies for its restoration and culture.

Figure 3.—*Strombus gigas* laying eggs in 3 m (10 feet) of water off the Bahamas.

Biology

Habitat

Queen conchs commonly inhabit sandy bottoms that are stable enough to support the growth of some of the numerous species of algae and seagrasses upon which they feed. They are also found on gravel, coral rubble, and smooth hard coral or beach rock bottoms. Queen conchs may be found in only a few inches of water or down to 76 m (250 feet), but they seldom go deeper than 30 m (100 feet) (Randall, 1964). Restriction of queen conchs to shallower water has generally been attributed to limitations of light for plant growth (Randall, 1964; Robertson, 1961). Small juvenile conchs ($<$ 80 mm or 3.2 inches) are often buried in sand during the day and are rarely seen (Randall, 1964).

Food

The queen conch is one of the largest of the herbivorous gastropod mollusks (Yonge, 1932), and uses a long, highly extendable proboscis to graze algae and seagrasses.

In general, Randall (1964) found that the dominant plants of a particular habitat in which conchs are found tend to be the principal foods. Although seagrasses such as *Thalassia* are consumed, various species of algae are the principal elements in the diet of *S. gigas*. Robertson (1961) observed conchs feeding on the epiphytic algae on *Thalassia* but found no *Thalassia* leaves in the gut. He noted four species of algae that were ingested by *Strombus*: an unidentified blue-green, *Cladophora* sp., *Hypnea cervicornis*, and *Polysiphonia* sp. Conchs may ingest considerable quantities of sand while feeding on filamentous and unicellular algae (Robertson, 1961; Randall, 1964). Small benthic animals found in the gut are believed to have been accidentally consumed (Randall, 1964).

Preliminary studies by Hesse[1] have found that food preferences of the queen conch change over the course of a year. Although probably due in part to variations in availability of plant species, apparently there is also a clear seasonal difference in the desirability of certain food sources. Feeding by conch during the night was reported by Randall (1964), and immature animals in particular tend to feed most actively at night, while often spending most or all of the day buried in the sand.

Reproduction

Copulation and spawning occur during the warmer months of the year (Brownell, 1977; D'Asaro, 1965; Randall, 1964), although in some areas reproductive activity may occur year round (Blakesley, 1977). Fertilization is internal. Under protection of the flaring lip, the penis is extended through the siphonal notch and up into the genital region (Berg, 1975). Randall (1964) observed conchs copulating at night as well as by day. Initial copulation precedes spawning by several weeks (D'Asaro, 1965; Randall, 1964).

Generally, females produce egg masses in clean coral sand with a low organic content. Production of the egg mass (Fig. 3) takes 24 to 36 hours (Randall, 1964; D'Asaro, 1965). The egg mass consists of a long continuous tube which folds and sticks together in a compact mass. Adhering sand grains provide camouflage. The number of eggs per egg mass has been estimated at between 313,000 and 485,000 (Robertson, 1959; Randall,

[1]Chuck Hesse, PRIDE, Pine Cay, Turks and Caicos Islands, B.W.I., pers. commun.

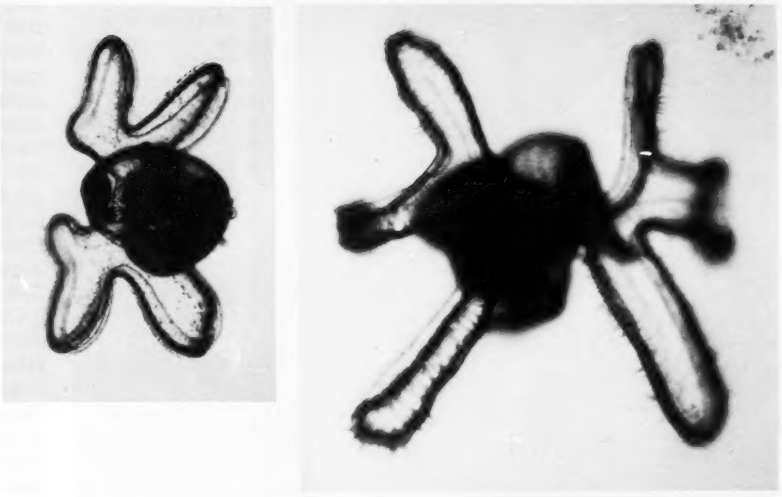

Figure 4.—Top left is a four-lobed *Strombus gigas* veliger showing beginning formation of third pair of lobes at 10-12 days old. Six-lobed veliger (top right) 15 days old. Below right is a settled larva just prior to metamorphosis. Foot can be seen at upper left of photo, below the shell.

1964; D'Asaro, 1965). Laying of more than one egg mass per breeding season by the queen conch and other *Strombus* sp. has been suggested by several investigators (Robertson, 1959; Randall, 1964; Berg, 1975).

The larvae, or veligers (Fig. 4), emerge from the egg cases after approximately 5 days (D'Asaro, 1965) and immediately assume a pelagic lifestyle, feeding on small phytoplankton. If conditions are right, the veligers settle to the bottom at 17-22 days after hatching, although they continue to be plankton feeders (Brownell, 1977). Metamorphosis is complete (development of the proboscis, disappearance of velar lobes) at 28-33 days (Brownell, 1977). However, larval development can be extremely slow if the supply of phytoplankton does not provide the appropriate types and quantities of required organisms (D'Asaro, 1965; Brownell, 1977).

Growth

Several investigators have estimated queen conch growth rates (Table 1). Estimates of mean length (tip of spire to distal end of siphonal canal) have ranged from 7.6 cm to 10.8 cm (3 to 4.3 inches) for yearling conch, from 12.6 cm to 17.0 cm (5 to 6.7 inches) at the 2-year mark, and from 18.0 cm to 20.5 cm (7.1 to 7.9 inches) at the end of the third year (Fig. 5, 6).

Table 1.—Calculated lengths of queen conch at 1, 2, and 3 years of age.

Lengths (cm) and years			Method of calculation (geographic location)	Reference
1	2	3		
8.8	12.6	18.0	Size frequency distribution of natural population (Puerto Rico)	Berg (1976)
7.6	12.8	18.0	Size frequency distribution of natural population (Venezuela)	Brownell (1977)
10.8	17.0	20.5	Von Bertalanffy growth curve analysis of Randall's 1964 tag/recapture data (St. John, U.S.V.I.)	Berg (1976) Brownell et al. (1977)
No data	17.0	18.6	Von Bertalanffy growth curve analysis of nine populations using tag/recapture data (Cuba)	Alcolado (1976)

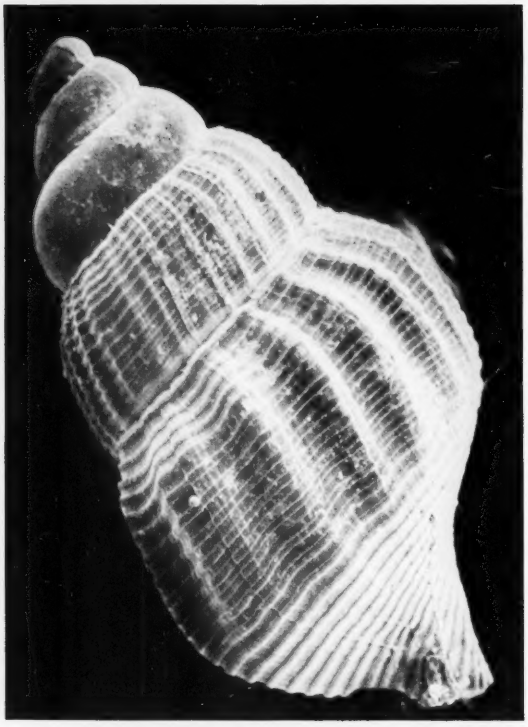

Figure 5.—A photomicrograph of a *Strombus gigas* juvenile 20 days after metamorphosis (4 mm long; 95 ×). Photo courtesy of Scott Siddall, Rosensteil School of Marine and Atmospheric Science, University of Miami.

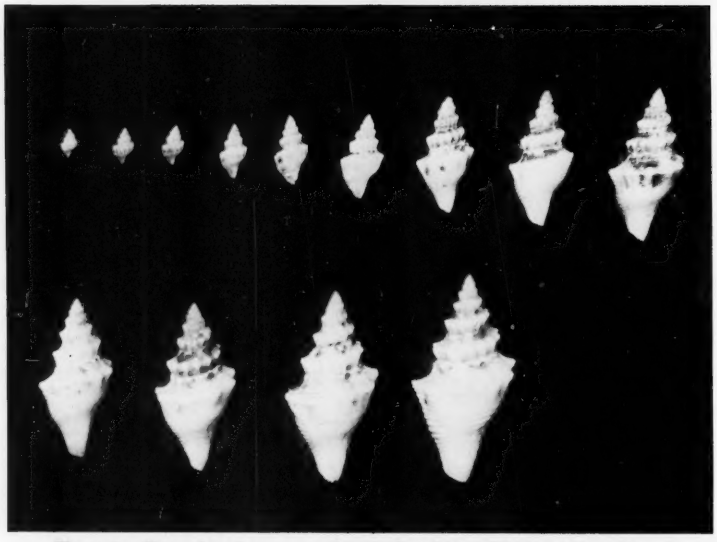

Figure 6.—Size series of queen conchs raised at the Los Roques, Venezuela, station (largest is 18.0 mm long). Photo courtesy of C. Berg.

Hesse[2] and Berg (1976) estimated that at an age of 2.5-3.0 years the conch stops building the shell in a spiral fashion and starts building the flaring lip (Fig. 1). At this time, the animal will continue to grow more meat, but at a much slower rate. Once the shell lip begins forming, more of the total weight is made up of shell weight and nonmarketable viscera. Queen conch most commonly reach an acceptable market size of 18.8 cm (7.5 inches), with a total weight of 845 g (29.6 ounces), and a meat yield of 100 g (3.5 ounces) at age 2.5 years (Berg, 1976).

Sexual maturity is attained after the flaring lip is well developed at an age of 3-3.5 years (Hesse, footnote 2; Berg, 1976). Thus, queen conchs reach marketable size before they are sexually mature. Berg (1976) estimated mean longevity to be 6 years.

Queen conchs with the broadest flaring lips are not the heaviest. When first laid down, the lip is thin and very broad. Soon, boring organisms and normal wear begin to erode the shell, and the thin outer lip crumbles. Periodically, what remains of the lip is repaired with new shell. A progressively shorter but thicker lip is the result (Randall, 1964).

Movements and Migrations

Parker (1922) described the unique locomotion of the queen conch. The conch thrusts its foot against the substrate, causing the shell to be lifted and thrown forward in a hopping motion. Berg (1975) suggests that this "hopping" motion may be of considerable adaptive significance. Most gastropods glide along by muscular waves of the foot, leaving a continuous chemical "scent" which enables night-feeding predaceous gastropods, octopuses, and crustaceans to "track" them; the conch's characteristic motion does not result in such a clear trail for these predators to follow.

[2]Hesse, C. 1975. The conch industry in the Turks and Caicos Islands. Unpubl. manuscr., 18 p. PRIDE, Pine Cay, Turks and Caicos Islands, B.W.I.

Field studies in the Turks and Caicos Islands by Hesse (1979) have greatly added to our understanding of queen conch movements and migrations. Queen conchs migrate seasonally: Inshore during spring and offshore during autumn. Seasonal regularity of migrations was found to increase with age. Hesse (1979) was also able to estimate a "home range" (area over which a conch habitually travelled when not involved in seasonal migrations) for different size classes. Juveniles from 10 to 13 cm (4 to 5.2 inches) long usually remained within a home range of 1,000 m^2 and most conchs from 13 to 16 cm (5.2 to 6.4 inches) exhibited ranges from 2,500 to 5,000 m^2. Conchs 17 cm long so often moved out of the survey area that meaningful home ranges could not be determined. Adult conchs appeared to range several kilometers. Tag-recapture studies yielded returns up to 2 km distant as little as 2 months after tagging. Tagged adults were found to commonly move a total linear distance of 50-100 m a day.

Hesse (1979) observed that conchs of all ages periodically bury into the substrate, often in response to winter storms. Longer term burying (up to 6 weeks) occurred independent of daily weather conditions and indicated periods of dormancy, which frequently occurred immediately prior to reproductive activity. Randall (1964) suspected that burying was mainly for the purpose of depositing new shell.

Figure 7.—Young conch divers working near Gran Roque Island, Venezuela. Photo courtesy of H. Lander.

Predation

Randall (1964) reported the following species as predators of the queen conch: Tulip shell, *Faciolaria tulipa*; Florida horse conch, *Plueroploca gigantea*; *Murex pomum*; hermit crab, *Petrochirus diogenes*; spiny lobster, *Panulirus argus*; spotted eagle ray, *Aetobatis narinari*; permit, *Trachinotus falcatus*; hogfish, *Lachnolaimus macunus*; queen triggerfish, *Balistes vetula*; and porcupine fish, *Diodon hystrix*. Eight species of fish (groupers, snappers, and grunts) with remains of queen conchs in their stomachs but without dentition to crush large shells led Randall (1964) to believe that these fishes had consumed queen conch after some other predator had made the soft part available. Hesse (footnote 2) indicated that octopus and perhaps nurse sharks also prey upon queen conchs.

Once the queen conchs are fully mature, predation by marine animals is apparently limited to large hermit crabs, certain sharks, rays, and sea turtles (particularly loggerheads), and possibly large octopus. Long before maturity (starting at a length of about 12 cm), the most dangerous queen conch predator is man.

Fishing Methods

Historically, sailing sloops 6-11 m (20-35 feet) long were used for harvesting conch. These sloops sailed to good fishing areas and several men fished from small dinghies. The bottom was scanned with a glass-bottomed bucket until a conch is located. A pole up to 9 m (30 feet) long was then used to hook the conch and bring it to the surface.

This method is currently practiced, to a limited degree, only in the Bahamas, Bermuda, and Turks and Caicos Islands. Fishing trips last 1-5 days, with the fishing grounds not normally being more than a 1-day sail away. The conchs are kept in corrals or in the live-wells of the boat until just before leaving for market with fresh meats. Sometimes they are taken to market in the shell. In the past, they were commonly dried in the sun or salt-dried during the fishing campaign.

Currently, small boats with outboard motors have become popular for getting out quickly to increasingly distant conch grounds (particularly in the Turks and Caicos). They are also an important status symbol for young fishermen. Traditional native boats with small inboard engines are still used in many places, such as Venezuela, Colombia, and the Dominican Republic. The fisherman's profit margin continues to decrease as both fuel consumption and costs increase, in spite of increasing conch prices.

Most fishermen today are free-divers (Fig. 7), using a face mask and fins to retrieve as many as eight conchs at a time, or to fill a heavy net bag to be hauled from the boat. A good

Figure 8.—Piles of discarded conch shells in the Las Aves Islands off the coast of Venezuela.

Figure 9.—Laughing gull perched atop a pile of conch shells left behind by fishermen in Los Roques Islands. Photo courtesy of H. Lander.

diver can gather 600 conchs in 4 hours of work on a productive ground in 3-7 m (10-23 feet) of water. But, since a very small portion of the remaining conch stocks can now be found in < 7 m (23 feet), many fishermen are turning to scuba gear for gathering in deeper water, thus increasing their harvesting costs and depleting the stocks even more. Most conch divers also gather lobsters, usually on different days or during different prescribed seasons.

Processing and Marketing

Nearly all present-day fishermen cut the animal out of the shell near the fishing grounds, either on the shore of a cay or in their boats. This allows the fishermen to carry more meat to market, and at greater speed. The meat is removed by knocking a small elongate hole between the third and fourth whorls of a spire. A narrow sharp blade is inserted in the hole, and the animal is cut free of its attachment to the central axis of the shell. A twisting motion can then be used to remove the animal. In order to keep the shell intact, shell collectors freeze or boil the animal (although boiling may result in fine cracks in the shell). The shells form huge mounds at popular meat removal sites (Fig. 8, 9), or are simply thrown overboard.

Conchs consumed locally are sold uncleaned from buckets at village markets. Processing plants, the majority of which are in Belize and the Turks and Caicos, prepare conch for export to the United States. Teams of cleaners remove the viscera and other soft parts from the muscular foot and peel away the tough dark skin. The cleaned meat is washed and placed in 2.3 or 4.5 kg (5 or 10 pound) plastic bags and cardboard boxes to be frozen, usually <12 hours from the time the animal was removed from the shell.

The waste is used occasionally as bait for fish pots. The marketable meat yield is about one-half the total weight of the shelled animal.

Frozen conch meat is usually shipped by airplane, although occasionally it is transported by lobster carrier boats or cargo ships. Most of it enters the United States through Miami (Table 2).

Status of the Resource

The importance of the queen conch fishery has been noted and reviewed by several authors (Doran, 1958; Menzel, 1969, 1971; Boss, 1971; Gunter, 1971). However, it has only been since the late 1960's that an import market for queen conch has developed in the United States, as greater numbers of Caribbean people migrated there (especially to New York City, south Florida, and California). Growing populations and tourism have also increased local de-

mand in countries which have traditionally consumed queen conch.

In Belize (previously British Honduras), queen conch rose from 2.2 percent of the value of fishery export products in 1965 to 23.7 percent in 1976, and the quantity of meat exported rose from 50,000 kg (110,000 pounds) to a peak of 561,000 kg (1,234,200 pounds) in 1972 (Blakesley, 1977). Although export of dried conch from the Turks and Caicos declined during the 1960's to the point of being considered unimportant by the local government, introduction of frozen meat to the U.S. market in the early 1970's resulted in a dramatic increase of queen conch landings (Hesse and Hesse, 1977).

Unfortunately, the available stocks of queen conch are insufficient to meet today's demand. Although conch meat imports through Miami more than doubled from 214,400 kg (471,680 pounds) in 1970 to 550,600 kg (1,211,320) in 1975, in recent years imports have leveled off (Table 2) in spite of rising prices. Blakesley (1977) reported that the export price of conch meat in Belize rose from 0.59 Belize dollars/kg in 1965 to 3.30/kg in 1976. In the Turks and Caicos, prices paid to fishermen rose from US$0.06 per conch in the 1960's to a 1978 price of US$0.18 per conch.

Higher prices and improved marketing structures have contributed to severe stock depletion in most of the principal fishing areas around the Caribbean. In Belize total exports declined to 211,000 kg (464,200 pounds) in 1978, considerably less than half the 1972 production. Reduced abundance has been reported in the Bahamas (Boss, 1971), the Grenadines and Puerto Rico (Adams, 1970), Turks and Caicos (Hesse and Hesse, 1977), and Venezuela (Brownell et al., 1977).

The Conch Fisheries

The following observations on the status of queen conch fisheries in individual Caribbean countries are mostly the result of a personal tour (July-September 1978) of the region by the senior author, sponsored by the FAO Inter-regional Project for the Development of Fisheries in the Western Central Atlantic (WECAF).

Antigua and Barbuda

Conchs are gathered all around Antigua and Barbuda. They used to be sent on flights from Barbuda to Puerto Rico until they became hard to find in the shallow waters of western Barbuda. Local demand is still being satisfied in Antigua, where conch meat sold for US$1.10/kg (US$0.50/pound) in 1978. Most conch collecting is now being done by native scuba divers, as the shallow water conch beds have been picked clean. Daily catch is loosely determined by the projected market demand, as the women from the villages who sell conch meat from buckets in the markets do not want to have any left over at the end of the day. Small quantities of conch are air-shipped to Guadeloupe, along with regular exports of iced fish.

Table 2.—Conch meat (× 100 kg) imported through Miami, 1970-78.

Country of origin	1970	1971	1972	1973	1974	1975	1976	1977	1978
Belize	145.7	265.0	382.9	245.1	376.7	330.5	222.5	159.9	135.8
Columbia	0	0	39.8	107.7	122.5	50.3	13.5	11.2	62.3
Dominican Republic	0	0	0.5	24.4	10.1	0.	2.1	0	0
Haiti	0	0	2.2	4.1	0	0.2	0.2	14.9	58.3
Honduras	58.0	32.4	88.2	83.4	5.7	36.3	57.7	3.7	21.4
Jamaica	0	0	1.5	4.1	28.5	40.7	0.8	0	0
Mexico	0.2	0	8.6	2.2	0	11.7	3.2	1.8	1.5
Turks and Caicos	2.0	2.3	0	0	0	65.9	150.9	221.7	262.8
West Indies	0	0	1.2	22.1	3.9	7.2	2.2	0	0
Other[1]	8.4	0.8	2.7	1.8	2.0	7.8	14.8	2.3	13.2
Total	214.3	300.5	527.6	494.9	549.4	550.6	467.9	415.5	555.3

[1]Bahamas, Cayman Islands, Costa Rica, Guatemala, Nicaragua, Panama, and Venezuela.
Source: National Marine Fisheries Service, Fisheries Development Analysis Branch, New Orleans, La.
Note: Approximately 27,000-32,000 kg of queen conch are imported to the United States each year directly through New York. Most of this comes from Belize, Honduras, and Colombia (J. Ledner, National Marine Fisheries Service, Fisheries Development Analysis Branch, New York, N.Y., pers. commun.). Less conch (in fresh or dried form) enters the United States on small boats, mainly in south Florida.

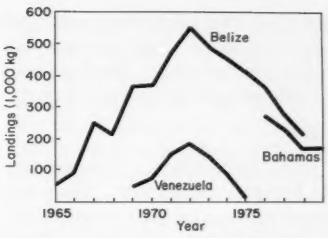

Figure 10.—Queen conch landings in the Bahamas, Belize, and Venezuela (meat weight). Sources: Bahamas (Henry Burrows, Bahamas Fisheries Department, Nassau, pers. commun.); Belize (Blakesley, 1977; data represent queen conch meat exported, estimated at 75-85 percent of total landings); Venezuela (Brownell et al., 1977).

Bahamas

Although conch landings in the Bahamas have declined (Fig. 10), there are still collection boats that work their way through the islands (especially around the Abaco, Andros, Berry, Eleuthera, and Exuma islands), buying conchs and delivering them to Freeport, Nassau, and Miami, either live or iced. Since fishable stocks within reach of villages and camps are depleted, fishermen are forced to either terminate their efforts or travel to distant grounds.

To insure maximum local utilization of the resource, export of Bahamian conch meat is prohibited. However, licenses are granted for the export of food products (conch fritters and chowder) that contain no more than 40 percent conch meat. Conch shell jewelry and crushed shell for terrazzo manufacture can also be legally exported. Retail prices in December 1979 averaged US$4.29/kg (US$1.93/pound), for conch meat, and reached as high as US$6.60/kg (US$2.97/pound) in winter[3].

Barbados

Apparently there never was an extensive conch population around

[3]Henry Burrows, Bahamas Fisheries Department, Nassau, pers. commun.

Barbados. Older fishermen remember only occasional small catches that were consumed locally. Single animals are still seen at times by scuba divers.

Belize

Conch production is monitored by the Fisheries Department. There is a closed season on conchs from 15 June to 30 September, and the minimum legal size is 18.8 cm (7.5 inches). A conch of this size yields 100 g (3.5 ounces) of marketable meat. Conch demand is high in Belize, but the high export market value (US$3.19/kg or US$1.44/pound for the year ending June 1978) means that most is frozen and sold abroad. Within the marketing range of the five fishery cooperatives in Belize, probably only about 10 percent (the minimum required by law) of the total catch reaches local markets. In the rest of the country all of the catch is sold locally, except for small quantities that are dried in fishing settlements near the Guatemalan border, and sold in that country by local traders. In such outlying areas, the catch rate is determined by daily market demand.

Conch meat exports from Belize (estimated at 75-85 percent of the total catch) rose sharply during the late 1960's, but has drastically declined in recent years (Fig. 3). Although conch meat exports have steadily declined since they reached a peak in 1972, rising prices have increased or maintained the value of export sales (US$716,790 in 1976).

Conch fishing effort has slightly increased every year since 1973, but the catch per diver per 4-hour day has decreased from about 36 kg (78.2 pounds) of meat in 1975 to about 11 kg (24 pounds) in 1978. Blakesley (1977) calculated the average size (shell length) of conchs caught to be 19.1 cm (7.6 inches) in 1976. In 1978-79 the managers of the cooperatives were very concerned about the large number of juvenile conch meats being delivered by fishermen, many in the 50-70 g (1.8-2.5 ounce) range, indicating shell lengths as short as 12.0 cm (3 inches).

Cuba

Conchs have been an important resource on the southern shelf of Cuba for many years. They are primarily consumed in coastal villages, are often used for bait in fish pots, and are not exported.

Dominica

Conchs have apparently never existed in significant numbers in Dominica, due to the very limited extent of stable, shallow bottom around the island. Most of the conchs accessible to free divers have long since been taken, but small numbers are still gathered when available by spearfishermen and are consumed locally.

Dominican Republic

The extremely narrow band of shallow water around the Dominican Republic is not conducive to high conch production. Nevertheless, the Fisheries Department estimated a catch of 132,339 kg (291,146 pounds) in 1977. More than half of the amount harvested came from the offshore banks (Mouchoir, Navidad, Silver, and the southern Bahamas).

Most of the Dominican artisanal fishermen based in the main north coast port (Puerto Plata) use hookah air systems for spearfishing and thus can gather conchs in deeper water than the average native fishermen. Two government agencies (Caza y Pesca and INDOTEC) are concerned about the conch fishery and have identified potential mariculture sites.

Grenada

The Grenada Grenadines and Grenada proper have traditionally been major suppliers of conch meat to Trinidad, Tobago, and Martinique. The Trinidad trade is basically finished, except for small amounts of conch that are shipped there from the nearly exhausted southeast coast fishery. The main conch grounds are in the north: Conference Point, Bedford Point, Carriacou, Petit Martinique, and all of the shallow waters surrounding the small islands in that area. Some fishermen keep conchs in natural corrals, bringing them in when the market is most favorable. Most conch divers now use scuba gear and work in depths averaging 12-15 m (40-50 feet).

Domestic conch consumption in Grenada is steady (7,000-9,000 kg or 15,400-19,800 pounds/year), even though the price has more than doubled in recent years. Domestic markets for conch meat are undersupplied by several tons each year. Quantities of conch meat equal to or greater than domestic consumption are shipped on ice through Union Island to Martinique markets[4].

Haiti

Despite severe overfishing, Haiti still produces enough conch to supply some local markets, and even to export substantial amounts to Miami. Haitians are traditionally the most dedicated consumers of conch in the Caribbean, and they account for a large portion of the sales of conch meat in Miami and New York. Even in 1943, when there was still considerable local production, Haiti imported 3,900,000 dried conch meats from the Turks and Caicos (Doran, 1958).

Panama

Conch is still important in the diets of residents of the Caribbean coast of Panama, especially in the San Blas Islands, where most of the fishing activity occurs. Most of the catch is consumed by the Cuna Indian fishermen, but some reaches the markets of coastal towns. Some gets exported along with spiny lobster to Miami, but exports are sporadic.

St. Lucia

There are many bays and backreef areas in St. Lucia that offer suitable habitat for conchs, but fishermen seldom find conchs in < 9 m (< 30 feet) of water anymore. Currently, they are taken mostly by scuba diving,

[4]Melvin Goodwin, Environmental Research Projects, Inc., New York, N.Y., pers. commun.

25-50 at a time, and are either sold locally or used for bait. Such efforts are very infrequent.

St. Vincent

The Fisheries Officer in St. Vincent is concerned about over-fishing of conchs, especially in the St. Vincent Grenadines, and wants to explore the possibility of raising them somewhere in those islands. No data exist on the current yield of the conch fishery in St. Vincent waters, but stocks have evidently been depleted everywhere. The once-flourishing Union Island fishery (Adams, 1970) now produces only a very limited quantity of conch, most of which is exported to Martinique.

Trinidad and Tobago

Trinidad has never been very productive for conch fishing, due to low salinities and high turbidity in shallow-water areas influenced by the runoff from the big continental rivers and the numerous Trinidadian streams. However, conchs were fairly abundant in Bombshell, Chacachacare, and Scotland Bays until they were fished out several years ago.

Demand for conchs is still high in Trinidad, but the supply is very limited. Only very rarely does a trader boat bring in a small load of iced or dried conch from nearby grounds (Grenadines or Los Testigos).

Tobago has traditionally produced enough conchs to supply local needs, but increased demand there and in Trinidad have led to severe overfishing. Fishing effort there is now very sporadic, mainly occasional collection of some deeper water conchs for sale to local hotels or for consumption by Tobago residents.

Turks and Caicos

For many years, beginning in the late 1800's, millions of dried conch meats were shipped from the Turks and Caicos Islands to Haiti (Dorna, 1958). Following World War II this trade began to decline. Early in the 1950's there was some export of frozen conch to the United States. However, in the mid-1950's, fishing effort was shifted toward the newly developed and more profitable export of lobsters. By the late 1960's and early 1970's, the Caicos conch trade was greatly reduced and was neglected by the local government. Queen conchs were fished principally for local consumption, lobster trap bait, and export to Haiti. The catch amounted to only 100,000-200,000 conches per year.

The importance of the queen conch fishery was reestablished in 1973 when export of frozen conch meat to the United States began again. Landings quickly increased in the following years. The exports of conch for 1976 totalled 1,900,000 individuals, valued at US$470,000. Though accessible stocks are rapidly being depleted, good catches are still being made, due to the fact that there are more fishermen with faster boats fishing far out on the southern and western edges of the Caicos Bank. In May 1978, the South Caicos processors were having a difficult time keeping up with landings, often having to clean and freeze 20,000 conchs or more in 1 day at each facility. Since the ex-vessel price was $0.18 per conch at that time, divers who gathered 400 conchs in a day (as is commonly done) had very good incomes.

However, the normal U.S. markets were over-supplied at that time (May 1978, just before the closed season started in Belize) and the processors were having to hold back more product than they had space for. The previously active trade in dried conchs to Haiti and the Bahamas is now virtually nonexistent, due to the greater profit associated with the export of frozen product to the United States.

Florida

Queen conch stocks occur along the Atlantic side of the Florida Keys north to the Palm Beach vicinity. They are occasionally seen along the lower southwest coast of Florida. In south Florida, queen conch is popular, and large quantities are used in fritters, salads, chowders, and fried as steaks. Highest recorded meat production was 25,503 kg (56,356 pounds) in 1966[5]. However, in recent years, often only ten kilograms have been landed, the result of harvesting restrictions imposed in 1971 due to concern over declining stocks (there is a limit of 10 queen conch per person per day[6]).

Conch meat imports through Miami are handled for distribution to retail outlets by approximately 24 wholesalers. Recent (November 1980) retail prices in south Florida, are commonly $7.15-$8.13/kg ($3.25-$3.65/pound) for cleaned, frozen meat. Two years ago retail prices at the same stores surveyed in 1980 ranged from $4.60 to $5.50/kg ($2.10 to $2.50/pound). Because of these high prices, harvesting restrictions are occasionally ignored and an undocumented amount of conch meat is sold by fishermen directly to restaurants.

Although strict harvesting restrictions have essentially eliminated commercial fishing, an undetermined number of conchs are harvested by sport divers. Conspicuous and easy to catch, the queen conch attracts the interest of even the most novice diver and is considered a prized souvenir. In view of its popularity in local seafood dishes and the fact that well over a million tourists visit the Florida Keys yearly, the recreational catch may indeed be considerable.

Venezuela

There used to be small numbers of conchs in some areas of the narrow Venezuelan shelf not excessively influenced by wave action and the runoff of rivers (such as Puerto Santo, Puerto Cabello, and San Juan de Los Cayos). These have been virtually eliminated by overfishing. Some conchs are still available in shallow waters around Los Testigos, Los Frailes, La Blanquilla, and La Tortuga. In La Orchila the conch populations are still extensive due to the fact

[5]Summary of commercial marine landings. Florida Department of Natural Resources, Tallahassee, Fla.
[6]Florida State Statutes, 370.113.

that the island is a military zone and the only fishing permitted is for sport by base residents and visitors. Los Roques and Las Aves de Barlovento y Sotavento still have extensive conch resources, in spite of heavy fishing pressure during the 10 years ending in 1974. Conchs are also present at Miniscule Aves (Bird) Island, but now only at depths >25m (>85 feet) where they cannot be reached by free divers.

Venezuelan production dropped from an estimated 180,000 kg (396,000 pounds) of conch meat in 1972 to 10,000 kg (22,000 pounds) in 1975 (Fig. 3), mainly due to a closed season and licensing of conch fishermen imposed by the National Fisheries Office. Still, much poaching occurs, especially in the isolated Las Aves Islands, from whence the catches can easily be carried directly to eager markets in Bonaire and Curacao. The reported catch for 1978 was 5,363 kg (11,800 pounds), but the actual figure probably would surpass 20,000 kg (44,000 pounds). The price in the La Guaira market in July 1979 was US $3.75/kg (US$1.69/pound).

By placing timely controls on the conch fishery, Venezuela has succeeded in maintaining the natural stocks in the Orchilla, Los Roques, and the two Las Aves archipelagos. However, the pressure is intense, even when the controls are working, and the conch populations could be virtually destroyed in a very short period of time if the controls were relaxed.

Mariculture

Because of increasing economic importance and concurrent reports of overfishing, the technical and economic feasibility of conch mariculture has attracted the attention of several investigators (Berg, 1976; Brownell et al., 1977; Brownell, 1977). These researchers have succeeded in raising conch from eggs through metamorphosis and have achieved normal growth and development with the resulting juveniles.

D'Asaro (1965) was the first to examine and describe queen conch larval development but was unable to rear larvae through metamorphosis, mainly due to nutritional limitations. Berg (1976) reported on growth of the queen conch and potential for mariculture.

Optimum larval density of 10 veligers/liter was reported by Brownell (1977) in a system of little or no aeration, inefficient removal of metabolic wastes, and a purely random assortment of food organisms. Larvae were raised on natural cultures of phytoplankton in large fiberglass tanks and aquaria with coarsely filtered, untreated seawater at a remote island research station. Films of algae coating the tanks and covering flat stones collected from the intertidal zone were utilized as food sources for juvenile conchs, which grew in length at a rate of 0.2-0.3 mm/day. Brownell (1977) also noted that under conditions of abundant food and absence of predators, juvenile conchs fed actively both day and night.

Even though these studies have demonstrated that queen conchs can be raised in captivity, considerable work still needs to be done before the proper techniques for conch culture can be defined. Once the technical practicality is demonstrated and conchs can be consistently raised in a hatchery situation, it still will have to be determined if mariculture is economically and environmentally feasible, either under intensive culture or for reseeding of depleted conch grounds.

Current and Proposed Research

In recent years, several researchers, particularly in Belize, Turks and Caicos, and Grenada, have studied habitat, food preferences, and migration behavior of queen conchs >7 cm (>2.7 inches) in length with the objectives of defining optimum environmental conditions, fishing pressure, and the potential for recuperation of overfished stocks. Such information is essential for helping local governments to establish effective management programs and for determining if conchs can be "farmed" in certain natural areas. Results of these studies have so far been inconclusive, due to the following difficulties:

1) Characteristic habitats are hard to define and even harder to map because the vegetation and bottom type undergo seasonal variations and the conch's preferences change as well.

2) Observation of conch densities and movements is limited by the animals' burying tendencies, unpredictable migrations, and periodic concentrations in deep water that are hard to survey.

3) Fishing activities cannot be controlled, since local fisheries departments throughout the Caribbean have little or no enforcement or record-keeping personnel; besides, fishermen are always reluctant to specify where they get their conchs.

The first comprehensive research on conchs was carried out by Randall (1964) in the Virgin Islands. Soon after, a basic conch fishery research program was initiated by the Belize Fisheries Department. Studies on stock density, length frequencies, distribution, harvesting rates, and landings have been carried out fairly regularly there since 1973. A new, expanded research project began in October 1980, primarily to study the biology of the species as it relates to practical considerations of productivity, growth rate, and increasing sustainable yields. The work is being carried out by the Belize Fishery Department with support from the Canadian International Development Research Centre[7].

The PRIDE (Protection of Reefs and Islands from Degradation and Exploration) Foundation at Pine Cay in the Caicos Islands is carrying out research on the rearing of conch larvae, the behavior and growth of subadult conchs in various types of enclosures, plus continuation of earlier work (Hesse, 1979) on conch ecology as it relates to fisheries problems.

PRIDE currently emphasizes mariculture research through two main approaches: Fundamental work at the

[7]H. Allsopp, Canadian International Development Research Centre, Vancouver, Canada, pers. commun.

wind-powered Pine Cay laboratory using filtered ocean water and controlled monocultures of phytoplankton plus a joint effort with the New York Zoological Society's Osborn Laboratory at the New York Aquarium using an established larval culture and monitoring facility. Both approaches have yielded some success in the rearing of small numbers of queen conch larvae. Much of this work is supported by the Griffis Foundation.

Environmental Research Projects, Inc.[8] (ERF) of Grenada has carried out field studies of conchs at Carricou since 1977 as part of a broad reef ecology and fisheries development program. In 1980 the ERF staff also did some larvae culture experiments. With primarily local people doing the research, ERF is searching for better sources of food and more effective holding systems for laboratory-reared larvae, studying the growth rates and feeding habits of juveniles under extensive culture conditions, and searching for natural nursery grounds of early juveniles. Most of this work, plus some of the PRIDE field work, is supported by the Rockefeller Brothers Fund.

A major research and development effort with emphasis on mariculture was planned by the U.S. National Marine Fisheries Service in collaboration with the University and the Government of Puerto Rico, plus some regional support from the FAO WECAF fisheries program. So far, the desired funding has not been acquired, but a preliminary effort was initiated in Puerto Rico with some support from the island's government and from the NMFS Aquaculture Program operating out of the Galveston, Tex., laboratory.

Three major proposals for conch research emphasizing mariculture have been submitted to Sea Grant (NOAA) since 1978. All were rejected for numerous reasons, the most important one being that there still is no clear indication that conch production can be increased through mariculture.

Another joint program for conch research was established in early 1980 by the Wallace Groves Aquaculture Foundation and the Rosenstiel School of Marine and Atmospheric Sciences (University of Miami). Field studies are being conducted on the growth and feeding of juvenile conchs (primarily 1-2 years old) at the Foundation's facilities in the Bahama Islands. Larval rearing is being carried out at an established molluscan culture laboratory at the University of Miami, to the specific culture conditions required which will eventually lead to hatchery-scale rearing.

Conclusions

Increased demand for conch has resulted in rapid expansion of fishing effort to the point where overfishing is now occurring. It is unlikely that current production levels can be maintained unless: 1) Currently intensively fished stocks can be managed to stabilize their presently falling levels of production; 2) conch culture and/or subsequent stocking prove to be useful for increasing production in overfished areas; and 3) new fishing areas can be located and utilized.

Due to rapid and severe declines in several major conch fisheries, a number of management regulations and export restrictions aimed at preserving the resource have been implemented by several countries. These include: Closed season (Belize), minimum size (Belize), requirement that a portion of the catch be reserved for local consumption (Belize), establishment of sanctuaries (Venezuela), daily catch quotas (Florida), and the prohibition of export of unprocessed product (Bahamas).

However, we believe that in some cases where queen conch stocks are clearly in peril, conch fishing should be terminated until adequate stock assessements can be made and sound management plans developed. Unfortunately, lack of biological information, and inadequate enforcement and recordkeeping personnel in local fisheries departments throughout the Caribbean, hamper development of a comprehensive management strategy.

Mariculture and/or stocking is a possible alternative for increasing or maintaining production. Conch larvae have been reared in the laboratory through metamorphosis. However, larval culture techniques suitable for establishment of pilot scale hatcheries are not yet available.

Existing research programs should be expanded enough to accurately evaluate the feasibility of both intensive and extensive mariculture practices. If it can be shown that it is possible to raise conchs consistently under controlled conditions with low capital investment, small hatcheries could be established at key locations, and local residents could be trained to operate them.

Because of the importance of the queen conch as both a source of food and money, it is important that significant efforts be made to save the resource. It is imperative that there be close cooperation and coordination among all appropriate research and management groups.

Note Added in Proof

In January 1981 the Wallace Groves Aquaculture Foundation sponsored a queen conch fisheries and mariculture meeting in Freeport, Bahamas, to bring together conch biologists and fishery managers and review conch fisheries, biology, and larvae culture, and define future research needs. Although recent successes with rearing conch larvae through metamorphosis were reported, more work is still needed to properly understand larval nutrition, triggering mechanisms for larval metamorphosis, and maximum rearing densities. At this writing, limited publication of the proceedings is anticipated.

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[8]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

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Habitat and Nursery Grounds of Pacific Rockfish, *Sebastes* spp., in Rocky Coastal Areas of Southeastern Alaska

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ABSTRACT—During late July 1978 we used a small submarine to explore the rugged rocky substrate along the coast of southeastern Alaska to depths of nearly 240 m (130 fathoms). The extensive boulder fields and pinnacle-studded bottom were populated mostly by rockfish, Sebastes *spp., of several species and a wide range of sizes. This untrawlable zone is a nursery area for rockfish, and dense schools of thousands of small 6-8 cm (2.5-3 inch) red rockfish were sighted at 90-100 m (49-55 fathom) depths over crevices and cover. Fish were less abundant in similar surveys of protected waters of a bay and fiord adjacent to the coastal sites.*

Introduction

The location of nursery grounds for juvenile Pacific ocean perch, *Sebastes alutus,* and most other rockfishes, *Sebastes* spp., in the North Pacific Ocean is poorly known. We have long suspected that the rocky, untrawlable areas along the rugged coastline of southeastern Alaska were important nursery grounds for Pacific ocean perch. These rough areas extend offshore on the continental shelf to a depth of 420 m (230 fathoms) or more. A few thousand juvenile rockfishes, primarily Pacific ocean perch, have been trawled nearshore in coastal bays and fiords of southeastern Alaska over steep slopes and ledges near rocky areas (Carlson et al.[1]). Incidental catches by commercial salmon trollers indicate that echosign over these areas is composed primarily of rockfish.

Offshore, beyond most of the rocky areas, Pacific ocean perch and several other rockfish species were heavily exploited by foreign trawlers (Major and Shippen, 1970) before U.S. management control (in 1977) over continental-shelf fisheries within the 200-mile limit. Neither foreign catches nor those of U.S. research vessels conducting resource surveys in these waters contained any early juvenile stages of Pacific ocean perch or other rockfish species (Lyubimova, 1965; Paraketsov, 1963; Ronholt[2]).

Pacific ocean perch and other rockfish species are ovoviviparous (livebearers) and are believed to release larvae in deeper water (Lyubimova, 1965; Gunderson, 1971). The planktonic larvae are transported to the nearshore waters by ocean currents (Lisovenko, 1964), a characteristic of the life history of many marine fishes (May, 1974), e.g., Dover sole, *Microstomus pacificus*; rex sole, *Glyptocephalus zachirus*; and petrale sole, *Eopsetta jordani* (Pearcy et al., 1977); English (lemon) sole, *Parophrys vetulus* (Ketchen, 1956); and darkblotched rockfish, *S. crameri*; canary rockfish, *S. pinniger*; and rosethorn rockfish, *S. helvomaculatus* (Richardson and Laroche, 1979).

The age that young of most rockfish species become demersal is not precisely known. Phillips (1964) captured young-of-the-year darkblotched rockfish and stripetail rockfish, *S. saxicola,* at 73-128 m (40-70 fathoms) while trawling for shrimp off northern California. Boehlert (1977) found that young splitnose rockfish, *S. diploproa,* move from surface to near-bottom waters during their first year of life in southern California. Some Pacific ocean perch become demersal by age 1, and most probably adopt a demersal existence in the nearshore coastal zone by the end of their first summer of life (Carlson and Haight, 1976). Recent evidence supports this idea. Twenty-five young-of-the-year Pacific ocean perch were captured in a bottom trawl in early October 1979 at 55-84 m (30-46 fathoms) in two fiords of southern Baranof Island and 28 more in late October 1980 at 73-128 m (40-70 fathoms) off northern Chichagof Island in southeastern Alaska (Carlson[3]). They ranged from 5 to 8 cm (2 to 3 inches) FL (fork length) and had just begun formation of the first annulus, marking the end of their first growing season.

The lack of young rockfish in offshore catches and their occurrence in catches at several nearshore locations led Carlson and Haight (1976) to hypothesize that the nearshore, rocky-bottom coastal areas and adjacent bays and straits of Alaska are nursery areas for Pacific ocean perch. Adult Pacific ocean perch reside in and

[1]Carlson, H. R., R. E. Haight, and K. J. Krieger. 1977. Species composition and relative abundance of demersal marine life in waters of southeastern Alaska, 1969-77. Processed rep., Auke Bay Laboratory, Northwest and Alaska Fisheries Center, NMFS, NOAA, P.O. Box 155, Auke Bay, AK 99821.

[2]Ronholt, L. L. 1979. Northwest and Alaska Fisheries Center, NMFS, NOAA, 2725 Montlake Blvd. East, Seattle, WA 98112. Personal commun.

[3]Carlson, H. R. Evidence for an early demersal existence of young-of-the-year Pacific ocean perch in southeastern Alaska waters. Unpubl. manuscr. avail. Auke Bay Laboratory, Northwest and Alaska Fisheries Center, NMFS, NOAA, P.O. Box 155, Auke Bay, AK 99821.

along gullies and canyons farther seaward on the outer continental shelf (Major and Shippen, 1970).

In July 1978, we used a small submersible to search for young Pacific ocean perch and visually survey fish in two rocky-bottom coastal areas exposed to open-sea conditions and in an adjacent bay and strait protected from open-sea conditions in the northern part of southeastern Alaska. This paper presents our observations of the behavior and habitat of young rockfish believed to be Pacific ocean perch, and describes the behavior and habitat of several other species of rockfish at various life stages.

Methods

The two exposed, rocky-bottom coastal areas were off Cape Cross on Yakobi Island and off Portlock Harbor on Chichagof Island in the northern part of southeastern Alaska (Fig. 1). The two protected areas were approximately 3 km (2 miles) inside Lisianski Strait in the Cape Cross vicinity and 1.6 km (1 mile) inside Portlock Harbor near its southern entrance. These four areas were selected as being representative of the coastal bottom topography of the northern part of southeastern Alaska after we conducted echo-sounding surveys in May 1978 in this region.

The areas off Cape Cross and Portlock Harbor were exposed to open-ocean sea and swell conditions, and the water was much clearer than inside Lisianski Strait and Portlock Harbor where waters were not as subject to oceanic influence and heavy seas and swells. The greater turbidity of the protected areas may be due to material suspended in the water from surface runoff and streams, and restricted circulation with the adjacent, clearer offshore waters.

We were fortunate to have unusually good weather during the survey period. Seas off the coast generally ranged from a gentle ocean swell to 1 m (3 foot) swells, which permitted launching and retrieval of the submersible without incident. Moderate to heavy seas, which frequently occur in this region, could render the submersible operation hazardous. Water visibility was outstanding on open-coast surveys and ranged from 10 to 23 m (33 to 75 feet). On the surveys inside fiords and bays, visibility was much less, being only 2-7 m (6-23 feet).

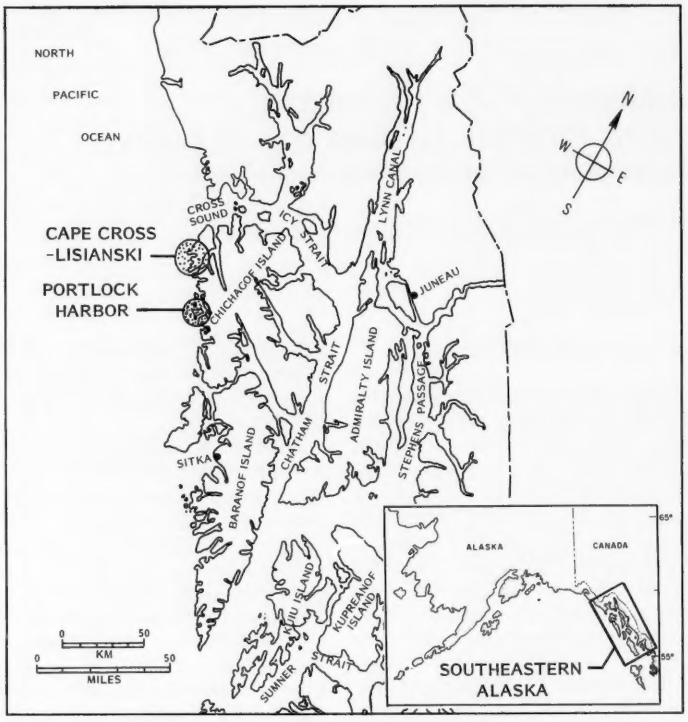

Figure 1.—Sites of surveys of demersal fish communities off southeastern Alaska, July 1978.

The submersible *Nekton Gamma* (Fig. 2), chartered from General Oceanographics[4] of San Diego, Calif., by NOAA's Manned Undersea Science and Technology Program Office, was made available to the authors from 21 to 28 July 1978 to conduct surveys beyond scuba depths (>40 m or >130 feet). The submersible is 5 m (16 feet) long, battery-powered, carries two persons, and can operate down to 305 m (167 fathoms) and operates at 1.8-5.5 km/h (1-3 knots) for 2-4 hours.

The transects at exposed coastal locations were plotted across uneven bottom located on earlier echo-sounding surveys. These transects were <6 km (3.7 miles) long and generally ran from shallow to deep water. We surveyed single transects <2 km (1.2 miles) long across the sites in Lisianski Strait and Portlock Harbor.

It was almost impossible to adhere to the coastal transects because of the extreme uneveness of the bottom (Fig. 3, 4). Navigating steep pinnacles and sheer ledges would have required frequent, rapid changes in depth largely beyond the capabilities of the submersible at its normal cruise speed of

[4]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

3.7 km/hour (2 knots). After some experience, we decided to cruise along the bottom for short distances and stop frequently to make observations when the submersible path was obstructed by abrupt changes in bottom topography. We followed transects across the center of the two inside protected sites without difficulty.

We identified in situ the types of substrate and fish species, estimated their sizes and relative abundance, and noted schooling behavior and reaction of fish to the submersible. Descriptions of the fish, their habitats, and behavior were recorded on a small portable tape recorder. Fish and their habitats were photographed in color with an externally mounted 35 mm Benthos Model 372 camera with flash. The camera was operated by the submersible pilot as subjects of interest came into view. We also used a portable video cassette camera to obtain black-and-white

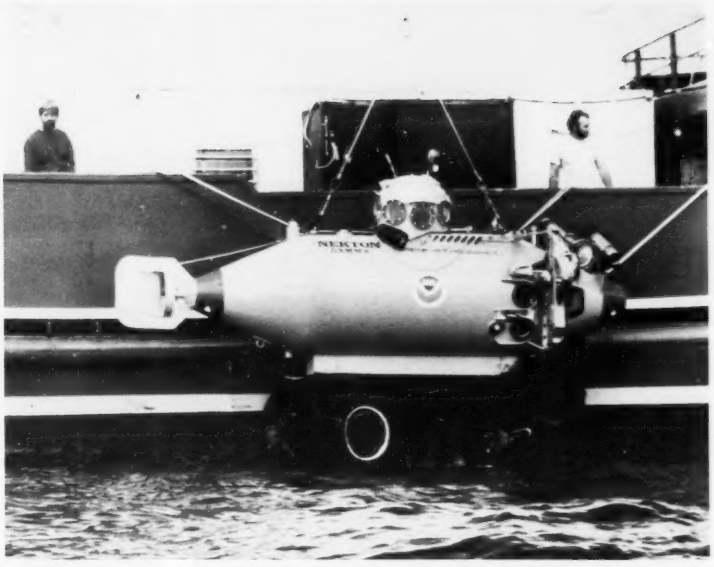

Figure 2.—The research submarine *Nekton Gamma* used to survey demersal fish in southeastern Alaska.

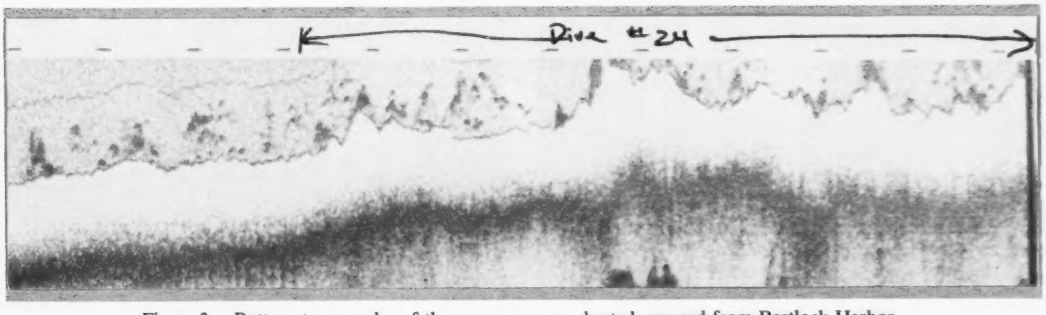

Figure 3.—Bottom topography of the survey area as charted seaward from Portlock Harbor.

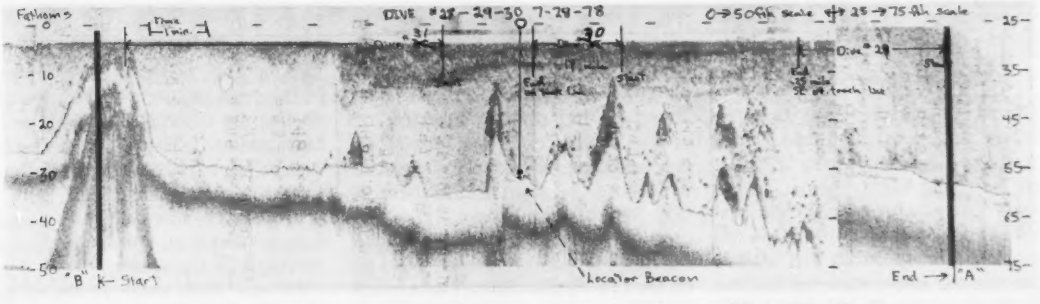

Figure 4.—Bottom topography of the survey area as charted seaward from Cape Cross.

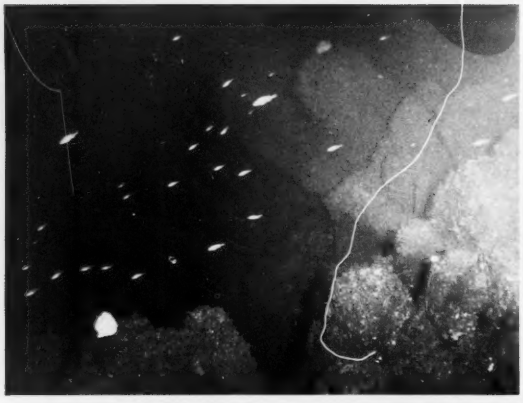

Figure 5.—Young rockfish over part of a steep, rocky pinnacle.

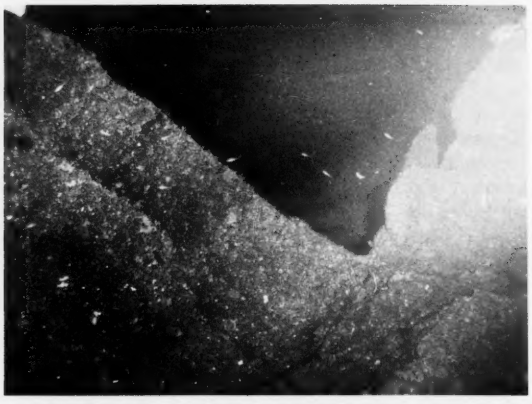

Figure 6.—Young rockfish and rugged, rocky substrate.

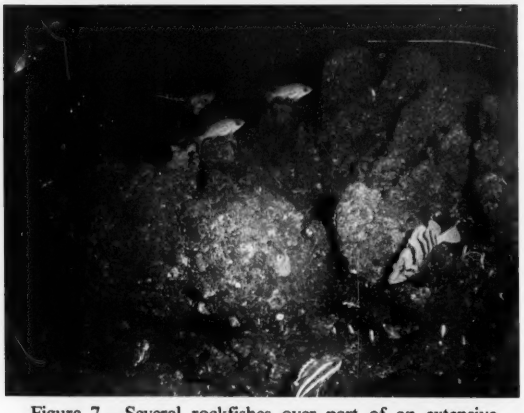

Figure 7.—Several rockfishes over part of an extensive boulder field. A young yelloweye rockfish is in the extreme lower right, a tiger rockfish to the right, and small unidentified rockfish to the upper center and upper left.

Figure 8.—A large (>2 m) wolf-eel moves slowly over a boulder field.

documentation of fish and their behavior.

Rockfish Nursery Area

Our most significant findings came from the surveys offshore from Portlock Harbor and Cape Cross (Fig. 1). Here we found what appeared to be nursery grounds for young rockfish. These schools were at 90-100 m (49-55 fathoms), over a bottom that varied from ragged, steep, rocky pinnacles (Fig. 5, 6) to extensive boulder fields (Fig. 7, 8) interspersed with areas of gravel-shell that were deeply furrowed, apparently by wave action.

Marine life in the rocky areas was abundant and diverse. Rockfish of several species and wide size-range predominated. Clouds of thousands of 6-8 cm (2.5-3 inch) reddish rockfish (Fig. 9), which we believe are Pacific ocean perch, extended as far as the limits of visibility (as much as 18 m or 60 feet) in all directions. These small rockfish were reddish with some darker blotching above the lateral line and generally had a slender body profile. They had no heavy spines evident in the head region; no black margin on fins; no distinct stripes, spots, or bars; and no disproportionate feature such as large eye, high dorsal fin, etc. Larger Pacific ocean perch have a pronounced symphyseal knob or projecting lower jaw, but this is not well developed in the young.

We saw other fishes in the rocky offshore areas (Table 1). Large

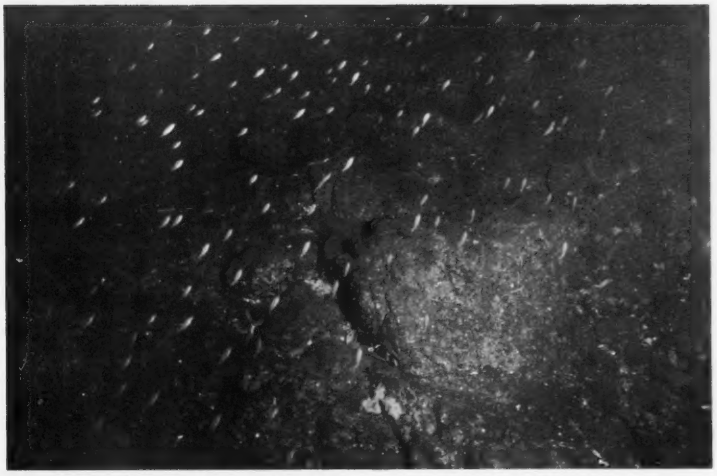

Figure 9.—Part of a dense school of young, 6-8 cm, red rockfish (believed to be *Sebastes alutus*) that extended to the limits of visibility over a rugged, rocky boulder field.

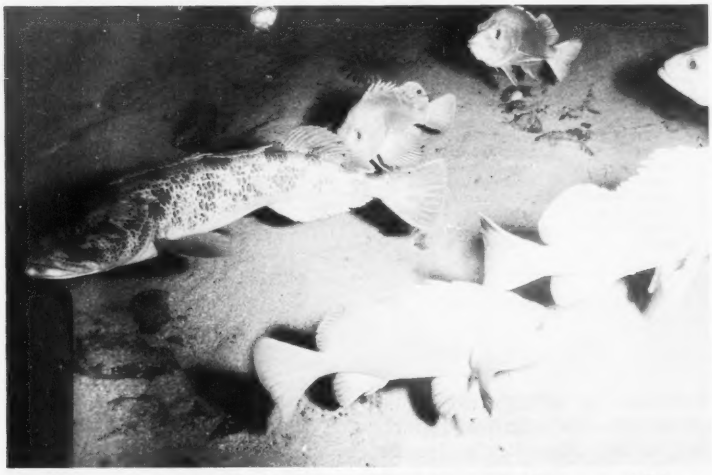

Figure 10.—A large (1 m) lingcod (left) and several yelloweye rockfish photographed over a portion of sand-shell substrate adjacent to rocky zones. Furrows in the sand (upper left) were apparently caused by surge action down to 90-100 m (49-55 fathoms). These rockfish were attracted to the submarine and examined it closely.

yelloweye rockfish, *S. ruberrimus* (Fig. 10), were abundant. Also present were yellowtail rockfish, *S. flavidus*; china rockfish, *S. nebulosus*; quillback rockfish, *S. maliger*; rosethorn rockfish; widow rockfish, *S. entomelas*; rougheye rockfish, *S. aleutianus*; tiger rockfish, *S. nigrocinctus*; and silvergray rockfish, *S. brevispinis*; as well as a few large Pacific halibut, *Hippoglossus stenolepis*; lingcod, *Ophiodon elongatus*; kelp greenling, *Hexagrammos decagrammus*; and wolf-eels, *Anarrhichthys ocellatus*. Small yellowtail rockfish, china rockfish, quillback rockfish, and either dusky rockfish, *S. ciliatus*, or black rockfish, *S. melanops*, were observed by scuba divers at 9-18 m (30-60 feet) inshore at Cape Cross (Barr[5]) at the same time as our observations; therefore, the nursery area probably extends into subtidal shallows.

Invertebrates in rocky offshore areas were not sparse but generally lacked variety. Frequently encountered were anemones, *Metridium senile* (Fig. 11); hydrocorals, *Allopora* sp.; sea stars (i.e., *Crossaster papposus, Henricia* sp., *Solaster* sp.); basket stars, *Gorgonocephalus* sp.; brittle stars; sponges; and bryozoans.

The two submersible surveys inside bays and fiords with entrance sills near the open coast, in Lisianski Strait and Portlock Harbor, covered depths of 18-240 m (10-130 fathoms). We found steep, rocky ledges that extended from nearshore and were overlaid with sand-shell at shallower depths and sand-silt at deeper depths. At deeper depths, we found a few isolated boulders and smooth rocky outcrops. At the inside sites, rockfish were not as abundant and fewer species were sighted. Most of the fish were types that lay in contact with the substrate, such as flatfish, skates, sculpins, and poachers. The only rockfishes sighted were a school of mixed large and small dusky rockfish in 18 m (10 fathom) shallows and isolated large individual rougheye rockfish, quillback rockfish, and Pacific ocean perch at deeper levels, ≥183 m (100 fathoms). We also saw a few large Pacific cod, *Gadus macrocephalus,* and large and small walleye pollock, *Theragra chalcogramma.*

Invertebrates were abundant and diverse at inside sites. Below 91 m (50 fathoms), pink shrimp, *Pandalus*

[5]Barr, L. P.O. Box 361, Auke Bay, AK 99821. Personal commun.

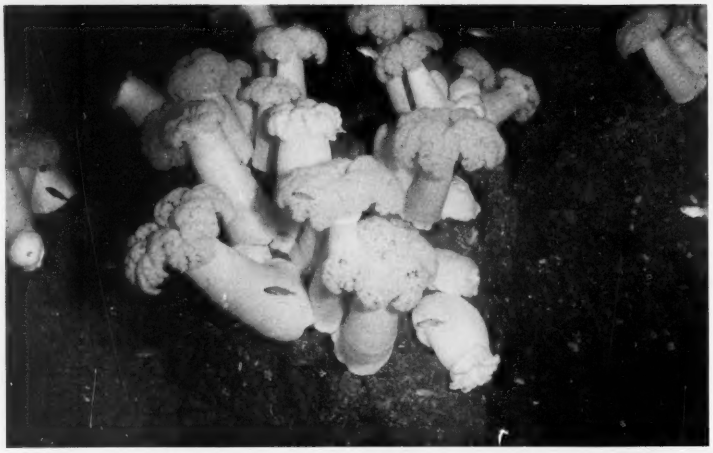

Figure 11.—Large white anemones, *Metridium senile,* growing on boulders, provide shelter for small rockfish, *Sebastes* sp.

Table 1.—Fishes observed during submersible surveys off the northwestern coast of Chichagof Island, Alaska, July 1978.

Common name	Scientific name	Common name	Scientific name
Rougheye rockfish	*Sebastes aleutianus*	Walleye pollock	*Theragra chalcogramma*
Pacific ocean perch	*Sebastes alutus*	Pacific halibut	*Hippoglossus stenolepis*
Silvergray rockfish	*Sebastes brevispinis*	Flathead sole	*Hippoglossoides elassodon*
Dusky rockfish	*Sebastes ciliatus*	English sole	*Parophrys vetulus*
Widow rockfish	*Sebastes entomelas*	Dover sole	*Microstomus pacificus*
Yellowtail rockfish	*Sebastes flavidus*	Big skate	*Raja binoculata*
Rosethorn rockfish	*Sebastes helvomaculatus*	Longnose skate	*Raja rhina*
Quillback rockfish	*Sebastes maliger*	Unidentified sculpin	*Triglops* sp.
China rockfish	*Sebastes nebulosus*	Blackfin sculpin	*Malacocottus kincaidi*
Tiger rockfish	*Sebastes nigrocinctus*	Sturgeon poacher	*Agonus acipenserinus*
Yelloweye rockfish	*Sebastes ruberrimus*	Blackfin poacher	*Bathyagonus nigripinnis*
Wolf-eel	*Anarrhichthys ocellatus*	Alaska eelpout	*Bothrocara pusillum*
Lingcod	*Ophiodon elongatus*	Coho salmon	*Oncorhynchus kisutch*
Kelp greenling	*Hexagrammos decagrammus*	Pacific sand lance	*Ammodytes hexapterus*
Searcher	*Bathymaster signatus*	Ratfish	*Hydrolagus colliei*
Pacific cod	*Gadus macrocephalus*		

borealis, were particularly abundant, and at least four other species of shrimp were seen, including sidestripe shrimp, *Pandalopsis dispar*. Octopus, nudibranchs, and gastropods were common, as were sea stars and anemones. Many small snow crabs, *Chionoecetes* sp., 1-4 cm (0.5-1.5 inches), were seen in or near the deepest part of Lisianski Strait at 227-238 m (124-130 fathoms).

Reaction of Fishes to Submersible

Most rockfish did not appear frightened by or attracted to the submersible with its lights and strobes that flashed intermittently. Notable exceptions were large yelloweye rockfish, which appeared to be attracted to the submarine and actually followed it around and cruised in close to peer in portholes. They appeared intrigued with the submersible. In one instance hundreds of these large, reddish, 7-10 kg (15-22 pound) fish trailed behind the submersible in a long column.

Large wolf-eels usually moved slowly away and appeared to beat a dignified retreat. Large lingcod briefly looked the submersible over at close range and swam off. Large halibut appeared curious but cautious and could not be approached closely. Schools of rockfish other than yelloweye rockfish appeared to behave normally and paid no particular notice to the submersible, unless we moved directly towards a school and then they moved off.

Conclusions

The rocky areas, exposed to open-sea conditions, that we surveyed are a haven or nursery ground for young rockfishes including Pacific ocean perch. This finding supports the hypothesis by Carlson and Haight (1976) that juvenile Pacific ocean perch inhabit these areas where cover and protection are afforded by cracks and crevices in and under rocks and ledges and among sessile invertebrates such as the anemone *Metridium senile.*

Near-bottom marine life differed in the two types of areas surveyed. In the exposed outer coastal areas, fishes predominated, primarily rockfishes of several species and life stages. In contrast, in the protected waters of an adjacent coastal fiord and bay, invertebrates predominated, primarily shrimp, small crabs, snails, sea stars, and anemones. Many species of invertebrates and most life stages were represented; fish were few in number and variety.

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Conditional Fishery Status as a Solution to Overcapitalization in the Gulf of Mexico Shrimp Fishery

VITO BLOMO

Introduction

Fluctuations in the economic health of natural resource industries are common whether managed or not. Agricultural, forestry, mining, and fisheries industries have all experienced boom and bust years due to environmental factors. When such fluctuations can be attributed to man-made factors, however, society and the industry itself can be expected to seek methods to eliminate or reduce them.

When industries exploit resources held in common, i.e., marine fish and shellfish stocks, there is a greater likelihood of man-made fluctuations than if the resources were owned privately. At the heart of this premise is the theory of common property resources, specifically put forth for fisheries by Gordon (1954) and Scott (1955). This theory demonstrates why more than the economic optimum level of harvesting inputs is used: Individual firms analyze their average returns instead of marginal returns (as affected by other fishermen) to make production decisions. Thus, economic returns from the resource are fully dissipated through larger than necessary costs.

A usual result of the common property resource situation is the overcapitalized state of the industry. Overcapitalization can be defined as the use of too many factors of production, or fishing effort, than is optimally profitable for the industry or economically efficient for society. This result is accelerated when the commodity's price increases faster than costs of operation. When public policy and resources contribute to overcapitalization in the industry, then all the participants suffer from less than optimal returns in even the best of years and society is not realizing the highest returns from its funds. Resolution of the overcapitalization issue can be addressed through regulations, economic incentives or disincentives, and a change in governmental fishing vessel programs which is called conditional fishery status.

The U.S. shrimp fishery, by virtue of its position as the most valuable U.S. fishery and of its investments and employment, has become a focal point of the U.S. fishing industry's poor economic condition in 1980 (Sullivan, 1980). Beset by escalating fuel costs and a sagging national economy and therefore demand for this luxury item, the Gulf of Mexico coastal area is particularly affected. This area accounts for the majority of the value, landings, fishing craft, and employment of U.S. shrimp totals (USDC, 1978).

The purpose of this paper is threefold: 1) To define a conditional fishery and outline the ramifications of a fishery being declared conditional; 2) to examine the present status of the Gulf shrimp fishery; and 3) to examine whether the Gulf shrimp fishery's characteristics qualify it as a conditional fishery. All objectives are complementary, but the last one serves notice that public resources (loan guarantees and income tax deferrals) should not be committed above economically efficient levels, i.e., above that point where excess vessel capacity exists.

Conditional Fishery

A conditional fishery is defined (Federal Register, 1973) as "a Fishery in which financial assistance for fishing vessels will be approved only under provisional terms consistent with needs and objectives of Management," as determined by the Director of the National Marine Fisheries Service (NMFS). Management refers to "activities related to assisting the fishing industry or protecting the Fisheries Resources," and is tied to the "wise use" provision of public funds in the Federal Ship Financing Act of 1972.

The financial assistance provided to the industry is in the form of: 1) Loan guarantees for vessel construction, reconstruction, or recondition, known as Fishing Vessel Obligation Guarantee (FVOG); and 2) income tax deferrals which go toward vessel construction or reconstruction, known as Fishing Vessel Capital Construction Fund (FVCCF)[1].

The motivation behind this public commitment can be traced to the Merchant Marine Act of 1936. The national policy behind the Act was the build-up of U.S. fishing fleets, provide for greater yields of seafood to an expanding populace, and provide for self-sufficiency of food supplies (thereby helping the balance-of-payments situation). However, the central theme of this paper calls this policy into question with regard to the shrimp fishery. The current situation in the fishery indicates: 1) Overcapacity (to be shown); 2) stable harvests disregarding environmental variations; and 3) decreased American

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[1]Financial assistance is also available from the Production Credit Administration (U.S. Department of Agriculture), Small Business Administration and Economic Development Administration (U.S. Department of Commerce). These are not discussed here.

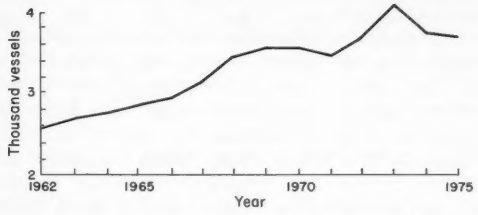

Figure 1.—Number of shrimp vessels in the Gulf of Mexico.

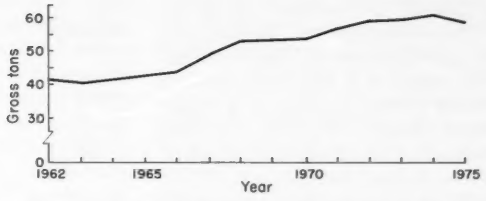

Figure 2.—Average gross tons of shrimp vessels in the Gulf of Mexico.

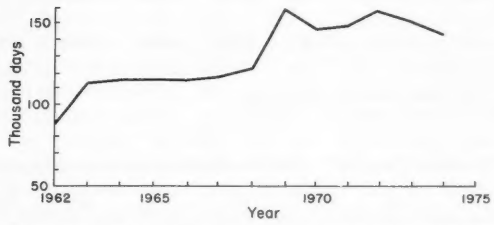

Figure 3.—Fishing effort in the Gulf of Mexico shrimp fishery, by vessels, in 24-hour units.

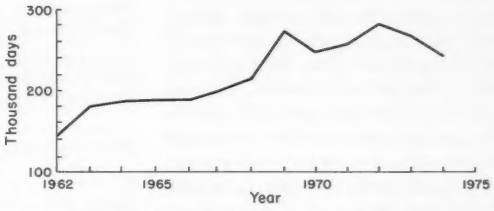

Figure 4.—Fishing effort in the Gulf of Mexico shrimp fishery, by vessels, adjusted for horsepower and footrope length of net, in 24-hour units.

effort in foreign waters with subsequent greater pressures in Gulf waters.

National policy (Federal Register, 1980) states that financial assistance, such as FVOG or FVCCF programs, will not be made unless it "is consistent with the wise use of the *fisheries resources* and with the development, advancement, *management*, conservation, and protection of the fisheries resources" (italics added). "When NMFS believes a fishery has too much vessel capacity, that fishery is adopted as a conditional fishery, provided other factors are not compelling enough to offset the vessel capacity factor."

After a fishery has been declared conditional, new applications for the FVOG and FVCCF programs will not be accepted. The exception to this is continuing the programs for "replacement capacity" of a standard vessel. Replacement of a standard vessel, however, has been given a liberal interpetation to allow, for example, replacement of a 45-foot wooden trawler—a standard vessel in the 1950's—with a 75-foot diesel-powered, twin-rigged, steel trawler—the current standard vessel. To date, seven fisheries have been declared conditional: 1) Pacific yellowfin tuna (10 June 1974), 2) Alaskan salmon (23 September 1974), 3) Alaskan king crab (22 September 1975), 4) west coast salmon (23 September 1974), 5) Gulf of Maine American lobster (23 September 1975), 6) surf clams (21 July 1977), and 7) Atlantic groundfish (22 January 1979).

Shrimp Fishery Trends

Analysis of the trends in the use of production inputs and their costs in the Gulf shrimp vessel fleet may lead to tentative conclusions about the shrimp fishery as a conditional one.

Vessels and Effort

The number of shrimp vessels has increased from 2,686 in 1962 to 3,690 in 1975, an average yearly increase of 2 percent (Gulf of Mexico Fishery Management Council, 1980). A record high 4,091 vessels occurred in 1973 (Fig. 1). The average size of a shrimp vessel has increased from 41.9 gross tons (GT) in 1962 to 59.3 GT in 1975, an average yearly increase of 2.6 percent (Fig. 2). The result of greater vessel numbers and larger vessel size is an increase in fleet capacity (Gulf of Mexico Fishery Management Council, 1980). Gulf shrimp catches, however, do not exhibit any upward trend.

Fishing effort has also increased significantly in the Gulf shrimp fishery. Nominal fishing days trawled (24-hour units) increased 50 percent between 1962 and 1974 (Blomo et al., 1978); a high of 67 percent was recorded in 1969 (Fig. 3). Total effort, defined as nominal fishing days trawled adjusted for growth in vessel horsepower and net size, increased even faster—69 percent between 1962 and 1974 (Blomo et al., 1978); a high of 96 percent occurred in 1972 (Fig. 4).

Capacity

Capacity is a concept useful for resource managers in analyzing the physical and economic use of production inputs. It is also cited above in NMFS criteria relating to a conditional fishery. Capacity, in both engineering and economic standpoints, is from Ballard and Blomo (1978).

The engineering aspect of capacity in the shrimp fishery can be measured through catch per unit effort (CPUE). The highest CPUE was in 1967: 494 pounds of shrimp per unit effort (Blomo et al., 1978). Assuming this catch rate to be 100 percent during 1962-74, capacity was as low as 53 percent utilization in 1973. If this catch rate per vessel (494 pounds) were maintained through 1975, the effect on the total number of vessels and revenue per vessel is dramatic when compared with the historical data (Table 1).

Another engineering capacity measurement is catch per GT. Again, its peak was achieved in 1967, 648.1 pounds of shrimp per GT. Recognizing the need for larger-sized vessels, Table 2 examines the effects on number of, catch, and revenue per vessel by maintaining the peak catch per GT and allowing for growth in vessel size (Fig. 2). The results are even more dramatic than those in Table 1. Catch and revenue per vessel are higher, while the number of vessels is significantly less[2].

Capacity from an economic standpoint would have maximum utilization where marginal revenue equals marginal cost (microeconomic approach). This would correspond to the economic optimum level of input use for each firm and for the (shrimp) fishery. Griffin, Lacewell, and Nichols (1976) estimated the economic optimum level of Gulf shrimp fishing effort for 1973. The results of this study indicated actual effort and vessel numbers were almost three times larger than would be economically optimum. Actual effort was still one-half as large as the effort which would earn the industry a "fair" return on its investment. Thus, from an economic standpoint as well, the industry is overcapitalized.

It is interesting to note that the Shrimp Fishery Management Plan (FMP), like other plans, utilizes the engineering aspect for estimating capacity. Capacity in the plan exceeds the expected domestic annual harvest, with a resultant zero foreign allocation. Use of the economic capacity concept could result in a foreign allocation in some circumstances if the optimum yield were not adjusted.

Table 1.—Maintaining 1967 shrimp catch per vessel: Effect on number of vessels and revenue per vessel.

Item	1967	1968	1969	1970	1971	1972	1973	1974
Total catch[1] (million lb)	99.7	83.7	82.4	96.1	91.3	94.3	71.0	73.9
Total revenue[1] (million $)	68.5	68.4	74.3	81.4	100.8	120.1	118.6	99.8
Historical catch per vessel (lb)	31,691	24,402	23,087	26,851	26,182	25,604	17,255	19,524
New catch per vessel (lb)	31,691	31,691	31,691	31,691	31,691	31,691	31,691	31,691
Historical no. of vessels	3,146	3,430	3,569	3,579	3,487	3,683	4,091	3,785
New no. of vessels[2]	3,146	2,641	2,600	3,032	2,881	2,975	2,240	2,332
Historical revenue per vessel ($)	21,773	19,941	20,818	22,743	28,907	32,609	28,990	26,367
New revenue per vessel ($)[3]	21,773	25,899	28,577	26,847	34,988	40,370	52,946	42,796

[1]Attributed to vessels, craft ≥ 5 GVT.
[2]Derived by dividing total catch (row 1) by new catch per vessel (row 4).
[3]Derived by dividing total revenue (row 2) by new number of vessels (row 6).

Table 2.—Maintaining 1967 shrimp catch per gross vessel ton: Effect on number of vessels and revenue per vessel.[1]

Item	1967	1968	1969	1970	1971	1972	1973	1974
Total catch[2] (million lb)	99.7	83.7	82.4	96.1	91.3	94.3	71.0	73.9
Total revenue[2] (million $)	68.5	68.4	74.3	81.4	100.8	120.1	118.6	99.8
Historical catch per GVT	648.1	464.8	429.9	499.1	453.0	432.5	289.7	317.5
New catch per GVT	648.1	648.1	648.1	648.1	648.1	648.1	648.1	648.1
Historical no. of vessels	3,146	3,430	3,569	3,579	3,487	3,683	4,091	3,785
New no. of vessels[3]	3,146	2,460	2,368	2,756	2,437	2,510	1,829	1,854
Average gross tons per vessel	48.9	52.5	53.7	53.8	57.8	59.2	59.9	61.5
New catch per vessel (lb)[4]	31,691	34,024	34,797	34,869	37,464	37,570	38,819	39,860
Historical revenue per vessel ($)	21,773	19,941	20,818	22,743	28,907	32,609	28,990	26,367
New revenue per vessel ($)	21,773	27,805	31,376	29,535	41,362	47,848	64,844	53,329

[1]Maintains total fleet tonnage at 1967 level, 153,840 GVT.
[2]Attributed to vessels, craft ≥ 5 GVT.
[3]Derived by dividing total catch (row 1) by new catch per GVT (row 4) by average gross tons/vessel (row 7).
[4]Derived by dividing total catch (row 1) by new number of vessels (row 6).

[2]Although catch is not linearly related to either vessel numbers or gross tons, the examples provided in Tables 1 and 2 illustrate a reduction in both in order to keep factor input utilization at historic maximum levels. A linear assumption would be invalid in expanding vessel numbers or gross tons with a resource having a maximum sustainable (or limited) yield.

Financial Conditions

Revenues and costs have varied for the Gulf shrimp fleet in past years. Revenues are a function of: 1) Landings, which are affected by environmental factors and the number of other vessels, and 2) price, which is affected by supplies and demand for shrimp. Costs fall into the variable (with fishing effort and catch) and fixed categories (Griffin, Wardlaw, and Nichols, 1976). Fuel, repair and maintenance of the vessel, and mortgage payments make up most of these costs that vary with effort. (Crew share costs vary with catch.) Annual fluctuations in revenues and costs will determine profitability for the fleet and individual vessels.

The financial condition of the shrimp fleet in various states has indeed fluctuated in past years. Costs and returns surveys of shrimp vessels demonstrate the volatility of profit. Blomo and Griffin (1978) found all sizes of Florida-based vessels earning profits in 1977, although the smallest sized vessels (28-54 feet keel length) incurred negative returns to the owner's labor and management. All sizes of Louisiana-based vessels earned profits in 1978 (Roberts and Sass, 1979). Vessels in Texas earned profits in 1971 and 1973, incurred losses in 1974 and 1975, and earned profits again in 1978 (Griffin, 1977; Griffin et al., In press).

The price of diesel fuel is perhaps the most visible production factor as well as the most likely to increase. Recent trends indicate a tripling in diesel fuel cost from 1974 to 1980 (Sullivan, 1980). Fuel efficiency rates relative to shrimp catch and value are calculated in Table 3, as well as percentage of total cost. This data provides a base from which to evaluate the impact on individual vessels from recent decreases in shrimp prices and increases in diesel fuel cost, and increasing fleet capacity as it decreases individual catches, ceteris paribus.

The implications on the future financial conditions of the shrimp fleet are quite sobering, considering that fuel has now at least tripled in price. Swartz and Griffin (1979) also examined rising diesel fuel prices and calculated the necessary annual catches for a shrimp vessel to break even. Their results indicated the necessity for substantially higher shrimp prices or larger annual catches than historically recorded. This, however, will be difficult given the present structure of the shrimp market and competition for the resource on the trawling grounds.

Under these circumstances, vessel owners are investigating and trying ways to increase fuel efficiency: Kort nozzles on propellers, hull coatings to reduce drag, use of more than two nets, changes in crew share arrangements, and use of fuel meters. The combination of excess capacity in the Gulf shrimp fishery, and deteriorating general economic conditions during 1979-early 1980 have caused shrimp vessels, particularly along the Texas coast, to be either: 1) For sale, 2) switching to swordfish/bluefin tuna longlining, or 3) tied up.

Until recently, the net accumulation of shrimp vessels has been at least partially due to the marginal rate of return on investment exceeding opportunity costs; this situation has occurred in 8 of the last 10 years. The poor financial condition of some vessel owners may have been due to the effects of increased costs which tend to emphasize diseconomies of scale common to the larger fleet operations. These diseconomies include that of managing hired captains, fuel storage for vessels, office expense and personnel, dock space costs, and possibly depreciation and insurance.

Table 3.—Fuel efficiency rates for various shrimp vessels in the Gulf of Mexico.

Area and vessel size	Fuel percentage of total cost	Lb of shrimp per gallon	$ of shrimp per gallon
Louisiana (1978)[1]			
Small vessel	13%	2.7.	4.04
Medium vessel	12%	2.0	5.00
Large vessel	21%	0.8	2.56
Florida (1977)[2]			
All vessels	16%	1.3	2.96
Wood vessels	16%	1.5	3.25
Small	13%	1.8	3.30
Large	16%	1.5	3.25
Steel vessels	18%	1.1	2.50
Texas (51 '-81 ' vessels)[3]			
1973[4]	13%		
1974 (33¢/gallon)	20%	0.8	1.37
1975 (37¢/gallon)	18%	0.9	1.96
1978 (41¢/gallon)	22%	0.8	2.35

[1] $0.40/gallon; from Roberts and Sass (1979).
[2] $0.42/gallon; from Blomo and Griffin (1978).
[3] From Griffin (1977); Griffin et al. (In press).
[4] Price not available.

Effect of Conditional Fishery Declaration

The trends in the Gulf shrimp fishery, namely vessel numbers and effort, capacity utilization, and its financial conditions, would force one to conclude that it does indeed qualify as a conditional fishery. Its overcapitalization and resultant application of excess effort and costs would seem to preclude the use of public resources to finance new or improved vessels.

Declaring a fishery conditional would have immediate and longer run effects. First, there would be an immediate cessation of the FVOG or FVCCF grants other than those existing and the "replacement capacity" described above. This would reduce present program activity by 50 percent (Greenfield, 1980). Presumably, other government loan programs (footnote 1) would be similarly affected.

In the short and possibly long term, the banking and credit community would be aware of the government's view of the fishery; this may affect the industry from the harvesting through the processing sectors. However, most other conditional fisheries have not experienced this; in fact, fleets have expanded in those fisheries through 1979 (M. Miller, NMFS, pers. commun.)

Policy Implications

The overt act of declaring a fishery conditional would address somewhat the overall problem of overcapitalization. Declaring a fishery conditional will not alleviate current problems such as factor cost increases or downturns in the national economy which affect demand for shrimp (Doll,

1976). FVOG and FVCCF programs in the past have accounted for only a small percentage (4-5 percent) of capital funds in the Gulf shrimp fishery (Greenfield, 1980). However, when the equity requirement for an applicant was decreased from 25 to 12.5 percent of the value of the vessel, the program accounted for 80 percent of new vessel construction and 8-10 percent of the total current fleet.

Programs which concentrate on all production factors—vessels and fishermen, primarily—would be more efficient. The value of discussing a fishery as conditional is that it may shift the discussion in the direction of total input use instead of additional inputs. FVOG and FVCCF could still be of value in this context if used only for refitting vessels to operate in other fisheries.

It may be that of the alternatives, conferring conditional fishery status would achieve the most benefits—reduction of fishing effort and more efficient allocation of public funds—with the least socioeconomic adjustments. It should be noted that the FVOG and FVCCF programs are self-adjusting, that is, during poor economic conditions new applications decrease substantially and the programs are not a major factor. However, presuming conditions improve, applications should again increase only to fuel future increases in fleet capacity and potential financial difficulties.

Another aspect of this issue is that the management of the fishery via the Shrimp FMP is essentially laissez faire. Consideration of conditional fishery status would be consistent with this philosophy by removing government distortions from the industry. Other more effective and efficient programs would thrust the Federal Government or the Gulf Council into active management of the industry.

Such programs which would concentrate on the factors of production involve economic incentives and/or regulations. These incentives and regulations include:

1) Permits for shrimping charged to fishermen; with these permit fees, offer financial incentives for shrimpers to go into other fisheries;

2) Landing quotas on vessels over a certain GT (or length) and a financial penalty per pound of shrimp over the quota, with proceeds acting as a financial incentive similar to #1 above;

3) Tax all new (or new above certain GT or length) vessels, levied at the shipbuilder level, with proceeds to go towards retiring older vessels;

4) Limited entry, with long- and short-term permits, and provisions for constraints on number of vessels, number of fishermen, fleet tonnage, average size vessel, or a combination thereof.

This list is not all-inclusive and is presented here for identification only. There are many issues associated with each program and each deserves adequate discussion as this dialogue on overcapitalization develops.

Summary and Conclusions

The Gulf shrimp fishery exhibits the classic symptoms of overcapitalization in an open access fishery enjoying high product prices. Analysis of the growth in vessel numbers and effort, the low rate of capacity utilization in engineering and economic terms, and the volatility of profits for what is essentially a luxury item appear to be adequate justification for conditional fishery status. Immediate effects of such status are denial of new applications for federal loan guarantee and income tax deferral programs. Longer term effects may include availability of credit from private sources.

Conditional fishery status will solve the problem of committing public resources in the shrimp fishery, of which the resource is common property. However, specific impacts would take several years in light of the fraction of the fleet which such vessels make up. There are other more efficient and effective programs, such as economic incentives and regulations, which would address the overcapitalization issue. Loan guarantee and income tax deferral programs may still be useful by diverting vessels into other fisheries, but their continued availability in the shrimp fishery is seriously questioned.

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U.S. Fishery Exports Top $1 Billion; Deficit Persists

United States seafood exports topped $1 billion in 1980 for the second consecutive year, but the nation sustained a fisheries trade deficit of $2.6 billion. The National Oceanic and Atmospheric Administration (NOAA) said fishery exports exceeded the billion dollar mark by $6 million. However, the agency said preliminary figures show imports totaling $3.6 billion. NOAA noted that last year's deficit was below the all-time 1979 high of $2.8 billion.

The agency said that although the 473,115 metric tons (t) of seafood products shipped during 1980 were 32 percent or 112,159 t above 1979 exports, they produced $76 million or 7 percent less in revenues. Edible seafoods valued at $904 million accounted for 90 percent of all exports, but were down 11 percent or $116 million from 1979. Nonedible fishery exports, mostly fish meal and oil, totaled 212,801 t and were valued at $102 million.

Japan again was the country's largest customer, purchasing 228 million pounds of edible products, or 40 percent of all exports, at a cost of $406 million. However, the Japanese bought fewer and less costly products than a year earlier; thus the dollar value of their purchases declined $162 million.

Pacific Ocean salmon was the most valuable export last year. It accounted for $357 million, or 40 percent of all foreign sales. The Commerce Department noted a $21 million increase in exports to four countries that U.S. trade missions visited last year to promote fisheries sales, especially stocks not favored by American consumers. Italy, Spain, South Korea, and Portugal mainly bought these "underutilized" species.

U.S. Albacore and Hawaii Skipjack Landings Down

Relatively poor fishing success marked the U.S. albacore fishery for the second consecutive year in 1980, according to Michael Laurs, Leader of the Albacore Fishery Program at the NMFS Southwest Fishery Center's La Jolla Laboratory. Landings through October 1980 were estimated to total a little over 8,000 tons. This is only slightly higher than the total landings made in 1979, and considerably below the seasonal 10-year average of about 23,000 tons.

There appear to be a number of factors contributing to the low landings of albacore in 1980 including: 1) The late arrival of the northern substock of fish into waters off the Pacific Northwest; 2) the failure of the fishery to develop fully off southern and central California despite an initial early appearance of fish; 3) the low availability of 12- to 15-pound (5.5 to 6.8 kg) fish off California south of Cape Mendocino (this size of fish normally makes up a significant portion of the U.S. catch), 4) fish not biting, in particular in the Cortes Bank and San Juan Seamount areas and off central California, and 5) high winds and rough seas hampering fishing effort, notably off California.

Some of the most consistent catches during the 1980 season were made during the last half of October. A fleet of approximately 75-100 jig and baitboats operated in the area centered approximately 140 miles off the coast between Pt. Sur and Pt. Arena. Catches were generally 0.5-0.75 tons per day for jigboats and 1-5 tons per day for baitboats, with top daily scores of about 1 ton for jigboats and 9 tons for baitboats. The fish caught were large, ranging mostly between 25 and 35 pounds (11.4 and 15.9 kg), with some fish over 50 pounds (22.7 kg) being landed. The catches were reported to have been made in waters with sea surface temperatures of 60°-61°F (15.6°-16.1°C).

Meanwhile, November 1980 Hawaii landings of skipjack tuna were estimated at 84.1 metric tons (t) and the December landings were estimated at 47.2 t. The cumulative landings for 1980 (January through December) were estimated at 1,470.7 t, which is 1,265.9 t below the 1979 landings and 2,092.7 t below the 1964-79 long-term annual average. Source: *Tuna Newsletter.*

Gulf, East Coast Marine Anglers: 300 Million Fish

Approximately 8.5 million saltwater recreational fishermen caught more than 298 million fish along the U.S. Atlantic and Gulf coasts during 1979, a NOAA survey shows. Most of the fish, approximately 192 million, were caught by anglers fishing from their own or rented boats. The number of fish caught at other locations were: Piers and jetties, 55.6 million; beaches, riverbanks, and sounds, 32.3 million; and from party and charter boats, 18.2 million. Half of the fish were caught in sounds, rivers, and bays.

The bluefish, *Pomatomus saltatrix,* was the most popular species. More than 27 million were caught, 15 million of them in New York, New Jersey, Delaware, and Virginia. Other major species caught off the two coasts included flounder, seatrout, spot, and croaker. More than 33,000 fishermen and 7,000 coastal area households were contacted during the survey conducted for NMFS.

Progress in Sea Turtle Protection

New Device Prevents Sea Turtle Drownings

NOAA's National Marine Fisheries Service (NMFS) has invented a mechanism to allow sea turtles to escape unharmed from shrimp nets without any appreciable loss of shrimp. "The device is a major step in the conservation of sea turtles," said Terry L. Leitzell, NOAA's Assistant Administrator for Fisheries. "Tests conducted by the National Marine Fisheries Service show that almost 90 percent of the turtles caught in the shrimp net escape when the device is used."

NOAA estimates that more than 2,000 sea turtles died along the East Coast last year. All were on the endangered or threatened species list. NMFS, the industry, and conservation groups have been working for several years to reduce turtle mortalities.

The device is installed in the throat of the shrimp net. As the sea turtle enters, it is deflected downward by bars which prevent it from entering the back end of the net. The vertical bars are angled to the rear and downward, forcing the turtle to settle on a trap door that opens under its weight and releases it through the bottom of the net. The device is expected to cost about $200 installed.

A NMFS laboratory in Mississippi developed the device over a 3-year period, testing it on shrimp vessels off South Carolina, Georgia, and Florida. The device also can be modified to allow fishermen more selectivity in the size and species of fish they catch. The NMFS is collecting information on the construction, handling, and use of the device for distribution to the shrimp industry.

Unique Headstart Program Aims to Save Sea Turtles

A species of sea turtle thought headed for extinction 3 years ago, may be on the road to recovery, thanks to a unique "headstart" program developed by NOAA's National Marine Fisheries Service. Since 1978, aquaculture specialists at a NMFS Southeast Fisheries Center laboratory in Texas have been raising hatchlings of the Kemp ridley turtle through the dangerous first year of life.

Lepidochelys kempi photograph by Larry Ogren.

About 95 percent of this year's crop of turtles has survived, reports James P. McVey, aquaculture division chief at the center's Galveston, Tex., laboratory and chief scientist on the headstart project. McVey estimates that less than 5 percent normally survive their first year in the ocean.

"All sea turtles are subject to intense predation," McVey said. "A baby turtle is a bite-sized morsel with no defenses. During that first year, until they become strong swimmers, they drift at the mercy of winds and currents which can take them into shipping channels or polluted harbors."

The Kemp, or Atlantic ridley, is one of seven sea turtles protected under the 1973 Endangered Species Act. Its primary western hemisphere nesting spot is a Mexican beach often raided by poachers seeking the ridley's eggs for their supposed aphrodisiac powers. More than 40,000 females nested on the beach in 1947. Despite a 15-year-old Mexican government program to protect the nests, only 200-500 nesting females remained there by 1978.

Now, in cooperation with the Mexican Instituto Nacional de Pesca, the U.S. Fish & Wildlife Service collects a few eggs each year for NOAA. These eggs are incubated in nests at Padre Island National Seashore. After hatching they are taken to the Galveston Laboratory and raised in tanks during the first year. This year's crop was released in May at Padre Island, McVey said. It brought the total number of hatchlings "headstarted" to more than 3,000.

Whether "headstarting" can save the Kemp's ridley from extinction will not be known for several more years, when the first group is expected to return to breed. However, the headstart program will continue to provide a captive brood stock of this endangered species, should it ever be faced with immediate extinction from some environmental disaster, McVey said.

Peruvian Fisheries Developments, 1980-81

Peru's fish catch declined to only 2.5 million metric tons (t) in 1980, a 30 percent decline from the 3.6 million t caught in 1979, and slipped to second place among South American fishing nations. The Ministry of Fisheries has implemented tough new regulations to protect sardine stocks.

Fishing Restricted

The Peruvian Ministry of Fisheries is restricting sardine fishing to allow stocks to recover from the effects of overfishing. Fisheries Minister Rene Deustua seems determined to follow more closely the recommendations of the Instituto del Mar (IMARPE) than previous governments, even though he is being severely criticized by the fishermen who would like to increase catches. Sardines have replaced anchovy as Peru's most important fishery, and the Ministry of Fisheries is attempting to manage sardine stocks more carefully than the decimated anchovy stocks were managed. One observer claims, however, that IMARPE really does not have precise data on the actual state of sardine stocks. IMARPE's acquisition of a new research vessel, the RV *Humboldt*, should allow the preparation of more accurate stock assessment estimates.

The Ministry of Fisheries authorized Peruvian fishermen to resume sardine fishing on 12 January 1981. The Ministry set a quota of 150,000 t for the first 3 months of the year, including 50,000 t for January. Fishermen who sell their catch to canneries and freezing companies will reportedly be allowed a quota of 600,000-700,000 t by the Ministry. Trade associations representing the companies are attempting to convince the Ministry to increase the quota to 1 million t. IMARPE initiated a new survey of sardine stocks to be completed by March 1981, when IMARPE was to make new recommendations on catch quotas.

Peruvian fishermen currently operate about 300 seiners which deliver sardines and other species to canneries and freezing plants. The Ministry of Fisheries has established a detailed schedule authorizing vessels from each port to fish only at specified times. The 104 seiners equipped with refrigerated seawater holds or other systems to preserve the catch may fish every week, Monday through Friday. The 158 seiners without any refrigeration system are only allowed to operate on alternate weeks.

The Ministry has given preference to the seiners which have systems to preserve the catch because they are able to deliver fish to the processing plants with much less spoilage than the seiners without such systems. The remaining 34 seiners which are based in the southern ports of Callao and Mollendo are allowed to fish every week, regardless of whether or not they are equipped with a refrigeration system. The Ministry has reportedly adopted less restrictive regulations for its southern fishermen because Chile continues to allow its fishermen to catch sardines and anchovies without restrictions. Largely because of the increased catch of sardines, Chile replaced Peru as Latin America's leading fishing nation in 1980.

Private Peruvian companies which can and freeze fish for human consumption are competing with PESCA PERU, the large state-owned fish meal company. PESCA PERU estimates that it will need to process at least 1.8 million t of fish (including sardines) just to cover costs. However, the Ministry has tentatively assigned PESCA PERU only a 1.0 millon t quota.

Private industry is very critical of PESCA PERU. Some businessmen would like to see PESCA PERU abolished. Others insist that the state-owned company should not be allowed to produce fish meal from species which could be used for processing edible products. Representatives of PESCA PERU counter that many private businessmen build small canning or freezing plants to justify the more lucrative processing of fish meal. The Ministry of Fisheries has attempted to limit illicit fish meal production by private companies. The Ministry has set minimum yields of canned and frozen products for every ton of fish purchased by the com-

panies from fishermen. The Ministry has determined minimum yields to be the best system to prevent the companies from diverting sardines and other valuable species to fish meal production.

Mixed Result for 1980

Peruvian fishermen caught an estimated 2.5 million t of fish in 1980, a 30 percent decline from the 3.6 million t caught in 1979. The 2.5 million t estimate is based on Ministry of Fisheries data which show a total catch of 2.35 million t through November 1980. As a result of the decline, Peru dropped to only the second most important fishing country in Latin America.

PESCA PERU reduced about 1.2 million t of fish in 1980 to fish meal and oil. The fish processed by PESCA PERU consisted of 0.6 million t of anchovy, 0.4 million t of sardines, and 0.2 million t of other species. The quantity of fish processed by PESCA PERU was one of the lowest in many years. Fishing to supply PESCA PERU's fish meal reduction plants was limited to the southern coastal area so that canning and freezing plants would have access to adequate supplies of sardine and other species.

Private companies processed 1.32 million t of fish in 1980, although 0.46 million t of that total was reduced to fish meal. The remaining 0.86 million t which was used to produce edible products set a record for Peru. Private canneries produced an estimated 8.4 million cases (48 cans each) of canned fish in 1980. Preliminary statistics reveal that Peru exported over $100 million worth of edible fishery products through November 1980, a 40 percent increase over the same period of 1979. Initial projections for 1981 are below 1980 levels. Industry sources believe, for example, that only about 7 or 8 million cases of canned fish will be produced in 1980.

Experimental Fishing for Jack Mackerel

The Ministry of Fisheries is attempting to promote fisheries for species other than sardine and anchovy to reduce the industry's dependence on those two species. The Ministry organized an experimental fishing expedition for jack mackerel 3-22 December 1980, claiming that fishermen should be able to take nearly 1.0 million t of that species. Over 85 small seiners participated in the expedition financed by the Ministry. Preliminary reports, however, indicate that the expedition was a failure. The seiners used by the fishermen were mostly built in the late 1960's and early 1970's for fishing anchovy close to the coast. The Ministry had hoped that new fishing techniques and gear would permit the seiners to be deployed for jack mackerel. As a result of the expedition, the Ministry is reportedly now convinced that the small seiners currently in the fleet are not capable of fishing in the deeper water where jack mackerel are caught.

New Commission

The Ministry of Fisheries established a new Fisheries Commission in January 1981 to prepare recommendations for a new national fisheries policy. The primary problem that the Commission will deal with is the conflict between PESCA PERU and the private companies which process edible products. The Commission is composed of three representatives of the Ministry of Fisheries and three leading businessmen, Guido Rossi, German Carmona, and Pedro Reatequi. (Source: IFR-81/30.)

Note: Unless otherwise credited, material in this section is from either the Foreign Fishery Information Releases (FFIR) compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR) or Language Services Biweekly (LSB) reports produced by the Office of International Fisheries Affairs, National Marine Fisheries Service, NOAA, Washington, DC 20235.

Pakistan Tells Joint Fish Venture Rules

The Pakistani Government has announced criteria which the Government will use to evaluate joint fishing ventures in Pakistan's 200-mile Exclusive Economic Zone (EEZ). Pakistan implemented the new regulations in December 1980 to encourage the formation of joint ventures with foreign companies. The new regulations permit the formation of joint ventures for not less than 1 year, beginning with the arrival of the foreign vessel in Pakistani waters. Under the regulations, the Pakistani Government can terminate any joint venture on 1 month's written notice.

Joint venture fishing will be allowed in Pakistani waters beyond 25 miles along the Sind coast and beyond 12 miles along the Baluchistan coast. No fishing will be permitted within Pakistan's 12-mile territorial waters to protect the interests of small-scale fishermen.

The percentage of equity to be shared by the Pakistani and the foreign partner, as well as terms relating to shared operations and expenses, is to be negotiated between the respective firms. The joint venture is required to pay the Pakistani Government a royalty equal to the value of at least 10 percent of the catch. The joint venture also has to maintain a foreign exchange bank account containing deposits equal to 30 percent of the value of the exports for payment to the Government. The marketing and export of the catch requires prior permission in writing from the Government and is subject to the prevailing rules and regulations at the time of export. Income from the joint fishing venture will be exempt from income tax until 30 June 1983; extensions of the tax exemption may be allowed by the Central Board of Revenue.

The joint venture companies are also required to crew any foreign-flag vessels with at least 50 percent Pakistani citizens while operating in Pakistan's EEZ to train Pakistan

fishermen in modern marine fishing techniques. Foreign vessels and their crews will also be subject to all Pakistani laws and regulations and will be liable to penalties prescribed therein. (Source: IFR-81/33.)

Caribbean Pollution and the Fisheries

The most serious pollutant in the Caribbean area is oil. One estimate suggests that nearly 7 percent of all offshore production is spilled through blowouts, overflows, pipeline accidents, and malfunctions. Other important pollutants are sewage, agriculture wastes, and industrial effluents. The Caribbean has the potential for developing coastal aquaculture, and artisanal fisheries are already important in most of the countries in the region. Both coastal aquaculture and artisanal fishing, however, are linked to coral, algal, sea grass, and mangrove habitats. It is these ecosystems that are mainly threatened by marine pollution and land reclamation.

The Western Central Atlantic Fisheries Commission (WECAFC) has prepared a 30-page study entitled "Review of Pollution in the Caribbean Region in Relation to Marine Artisanal Fisheries." The report surveys the hydrography of the region, major pollutants, artisanal fisheries, fishery stocks, and fisheries endangered by pollution. A copy of the report can be requested from Dennis Weidner (F/IA1), NMFS, NOAA, Washington, DC 20235, enclosing a large self-addressed envelope with $0.50 postage.

Yaizu 1980 Tuna, Billfish Landings Up 21 Percent

Tuna and billfish landings at the leading tuna port of Yaizu, Japan, during 1980 totaled 180,385 metric tons (t) valued at ¥84,316 million ($376 million at ¥224 = US$1), according to the Yaizu Fishery Cooperative Association. The landings were up 31,806 t or 21 percent from the landings in 1979. The increase was due primarily to gains in southern bluefin, yellowfin, bigeye, and skipjack tuna landings. Ex-vessel prices per short ton of tuna at Yaizu in 1980 averaged $1,668 for albacore, $2,041 for yellowfin tuna, and $1,239 for skipjack tuna. (Source: FFIR 81-3.)

Tuna and billfish landings and average ex-vessel prices at Yaizu, Japan, 1980.

Species	Landings (10^3t)	Value (10^9¥)	Avg. ex-vessel price[1] ¥/kg	$/ST[2]	$/t
Bluefin	1.2	1.4	1,191	4,823	5,316
S. bluefin	9.3	18.7	2,005	8,120	8,950
Bigeye	12.1	9.0	742	2,932	3,312
Yellowfin	22.9	11.5	504	2,041	2,249
Albacore	25.9	10.7	412	1,668	1,839
Swordfish	0.7	0.5	726	2,940	3,241
Marlin					
Striped	0.4	0.3	770	3,118	3,437
Blue	0.9	0.5	520	2,105	2,321
Black	0.1	0.05	469	1,899	2,093
Skipjack	0.05	0.02	306	1,239	1,366
Other[3]	106.9	31.7			
Total[4]	180.4	84.3			

[1] Based on ¥224 = US$1.
[2] ST = short ton.
[3] Other includes small tuna and some billfish.
[4] Totals may not add up due to rounding.

Japan's 1980 Fishery Imports Down 10 Percent

Japanese imports of fishery products in 1980 declined both in quantity and value from the preceding year on a customs clearance basis, according to the Japanese Finance Ministry. At 1,037,350 metric tons (t) valued at ¥764,272 million ($3,411 million at ¥224 = US$1), the 1980 imports were down 10 percent in quantity and 18 percent in value from 1979.

Decline in quantity was particularly severe for pollock roe (down 58 percent), squid (down 40 percent), herring roe (down 30 percent), salmon (down 18 percent), crab (down 17 percent), tuna (down 19 percent), shrimp (down 10 percent), abalone (down 52 percent), and jellyfish and sea cucumber (down 55 percent). An increase in imports occurred for eel (up 15 percent), salmon roe (up 10 percent), and octopus (up 1 percent).

Frozen shrimp imports, which totaled 143,256 t worth $1,073 million, led all other imports both in quantity and value, accounting for 14 percent in quantity and 31 percent in value of the total fishery imports. (Source: FFIR 81-5.)

Japan's Surimi Products Down 2 Percent in 1980

Japanese frozen "surimi" (minced fish meat) production during January-December 1980 amounted to 288,900 metric tons (t), down 2 percent from the 1979 figure. Of this quantity, 183,232 t or 63 percent consisted of high-seas production (motherships and independently operated large trawlers) and 105,668 t or 37 percent, land-based production. Land-based surimi production in 1980 fell 8 percent from 1979, whereas high-seas production surpassed the 1979 output by 2 percent. The historical trend in the production of surimi during 1969-80 is shown in the table below. (Source: FFIR: 81-5.)

Japanese imports of fishery products, 1959-80.

Year	Metric ton	¥ Million	Year	Metric ton	¥ Million
1959	19,270	2,766	1970	374,568	114,628
1960	47,476	5,523	1971	398,071	153,347
1961	56,634	8,173	1972	480,649	190,338
1962	89,623	10,694	1973	658,425	300,072
1963	156,330	21,385	1974	604,141	323,239
1964	232,120	32,266	1975	710,373	385,008
1965	278,939	37,422	1976	813,430	563,884
1966	333,799	60,331	1977	1,045,610	657,700
1967	330,949	68,966	1978	1,018,894	675,600
1968	370,143	72,134	1979	1,151,174	930,738
1969	362,627	93,844	1980	1,037,350	764,272

Japanese frozen surimi production, 1969-80, in metric tons.

Year	Land-based	High-seas	Total
1969	92,718	103,610	196,328
1970	118,521	142,802	261,324
1971	137,847	183,534	321,382
1972	155,868	191,145	347,013
1973	159,146	223,599	382,745
1974	157,555	195,297	352,852
1975	191,729	169,036	360,765
1976	187,806	195,311	383,117
1977	168,823	191,769	360,592
1978	132,433	183,012	315,445
1979	114,426	180,402	294,828
1980	105,668	183,232	288,900

New Zealand's Fisheries and Fish Exports Expand

New Zealand's fishing industry has grown rapidly in recent years. Finfish landings increased from 48,000 metric tons (t) in 1974 to 76,000 t in 1979. New Zealand's finfish exports have also increased, breaking the industry's dependence on lobster. Finfish exports exceeded lobster exports in value for the first time in 1978. Exports of all fishery products totalled 65,000 t valued at $98 million in 1979, a fourfold increase since 1974. Finfish exports total about half of all fishery exports. New Zealand now exports its fisheries products to over 40 countries.

The New Zealand industry has relied on small coastal fishing vessels for years. New Zealand fishermen, since the country declared a 200-mile Exclusive Economic Zone (EEZ) in 1978, have developed offshore fisheries for demersal species which have previously been fished only by foreigners. New Zealand companies are acquiring modern new vessels and building modern processing plants. Joint fishing ventures between New Zealand companies and foreign fishing interests have provided New Zealand's fishermen experience with large vessels, deepwater fishing techniques, and access to new markets. New Zealand has potential for still more expansion. Its 200-mile EEZ is one of the world's largest. The Government believes that an annual harvest of 250,000 t of finfish and 100,000 tons of squid may be possible.

Further, the New Zealand Fishing Industry Board reports that the country's fishery exports have increased by approximately 500 percent during the last decade. In 1970, the country's exports of fishery products amounted to 10,700 t valued at NZ$17 million[1]. By 1979, these exports had increased to 65,000 t and were worth NZ$98 million[2]. Although all fishery exports were higher priced in 1979, the total value of fishery exports increased only as much as the volume exported. This is due to the fact that more lower priced, underutilized species were exported in the late 1970's.

The increasing quantity of landed fish sold for export can be attributed to the considerable expansion of the fishing industry and the development of joint ventures. Of the NZ$98 million worth of fishery exports in 1979, over NZ$26 million (about 27 percent) was contributed by New Zealand companies chartering vessels in joint ventures with foreign companies.

Also helping to increase New Zealand fishery exports was an expansion into new and rapidly growing markets and a diversification in the number of species caught. In 1979, New Zealand's three main markets—Japan, the United States, and Australia—accounted for 70 percent of the nation's fishery exports. This was, however, a significant decline from 1970, when exports to these three countries were 90 percent of total fishery exports. Fishery exports were diversified into new markets in southern Europe, West Africa, and the Middle East.

Japan imported NZ$28 million of New Zealand fishery products in 1979, almost double the 1978 amount. Japan is now New Zealand's largest market; the main export commodities were snapper and squid. However, because of the erratic demand in the Japanese markets, New Zealand hopes to decrease this dependence and diversify its export markets. The United States was overtaken by Japan in 1979 as a major New Zealand export market, but it still remains important to New Zealand fish exporters because of its role as a price-setter for many commodities. The United States is increasing its traditional imports of rock lobster which amounted to NZ$21 million in 1979, compared with NZ$11 million in 1970.

Australia was New Zealand's major market for finfish in 1979. Over 85 percent of the NZ$17 million exported to Australia in 1979 were finfish. Exports in 1979 increased by 55 percent over 1978 levels.

Three new markets have begun to emerge, and hold promise for the future. Government-industry Export Opportunity Teams visited southern Europe and West Africa in 1979 to promote New Zealand fishery exports.

Southern Europe bought NZ$11 million in 1979 compared with only NZ$4 million in 1970. Most of these exports went to Spain, Greece, and Italy. West Africa is also attracting New Zealand fish exporters because it offers a large market for the lower-priced, high-volume species which are now being caught in greater quantities. And, the large expatriate work force in the Middle East oil countries is also attracting New Zealand exporters, but the long-term market potential there is still uncertain.

In 1979, the major species exported were snapper; tuna; eels; flatfishes; red cod, *Pseudophycis bacchus*; hoki, *Macruronus novaezealandiae*[3]; and barracouta. The most substantial growth in exports occurred in less familiar species such as hoki; red cod; barracouta; mackerel; kahawai, *Arripes trutta*; ling; and warehou, *Seriolella* sp.

Rock lobster exports amounted to NZ$27 million in 1979, or 28 percent of the total exports. This contrasts sharply with 1970, when exports of rock lobster accounted for 72 percent of New Zealand's fishery exports. On the other hand, other shellfish exports increased from 3 percent of the total in 1970 to 17 percent in 1979. Squid comprised the bulk of 1979 shellfish exports, whereas in 1970 abalone and scallops were the most important shellfish species.

The growing exports of air-freighted refrigerated fish during the last few years is also a major development. In 1979, these exports were valued at NZ$11 million and are expected to increase rapidly as general air and specialized freight services, primarily to Japan, continue to grow.

[1] NZ$1.00 = US$1.115 (1970).
[2] NZ$1.00 = US$1.023 (1979).
[3] Also known as the New Zealand whiting.

A Symposium on North Pacific Salmonid Ecosystems

"Salmonid Ecosystems of the North Pacific," edited by William J. McNeil and Daniel C. Himsworth, contains the papers presented at a symposium of the same title held at Otter Crest, Oreg., in May 1978. The symposium was suggested by R. L. Edwards, Director, NMFS Northeast Fisheries Center as an activity of the Joint U.S.-U.S.S.R. Working Group on Biological Productivity and Biochemistry of the World Ocean. The symposium was organized to accommodate subjects relevant to freshwater, estuarine, and marine ecosystems; population and community dynamics; and artificial propagation of Pacific salmonids. The proceedings include 17 papers delivered by prominent American and Canadian fisheries scientists as well as abstracts of 7 papers submitted by Soviet scientists.

Topics covered include testing for density-dependent marine survival, juvenile salmonids in the oceanic ecosystem during the first summer, trends in North Pacific salmon fisheries, marine mammal-salmonid interactions, trends in Puget Sound and Columbia River salmon, vulnerability of pink salmon to natural and fishing mortality, and ocean migrations and timing of Pacific salmon.

Other subjects are the feeding ecology of young Lake Washington sockeye salmon and the salmon enhancement problem, salmon outmigration studies in Hood Canal in 1977, ecology of juvenile salmon in Georgia Strait, primary productivity of the North Pacific, estuarine influences on young Bristol Bay sockeye salmon, density-dependent growth of Bristol Bay sockeye salmon, population structures of Pacific Northwest salmonids, selection to increase yield of coho salmon, chum salmon responses to artificial propagation, and the pineal gland and migratory behavior.

An appendix presents the following abstracts of Soviet studies: Growth of young sockeye of different year classes and fluctuations in primary production in Lake Dalneye, cranial anatomy of Far East salmon in postembryonic ontogenesis, assortive crossing and the role of sex ratio during the spawning period of Pacific salmon, problems of Pacific salmon population biology, *Hucho perrui* of the Kievka River, age structure of subisolates of sockeye salmon in the first generation, and biochemical genetics of populations of Pacific salmon.

Thus the articles present both current research on Pacific salmonids as well as several important reviews summarizing several years of extensive research. As such, the volume is a valuable addition to Pacific salmonid literature and will be of interest to fisheries scientists and administrators, salmon "ranchers," marine biologists and others seriously interested in the future of these species.

Indexed, the 342-page paperbound 8½ × 11-inch volume is available from the publisher, the Oregon State University Press, 101 Waldo Hall, Corvallis, OR 97331 for $15.

Techniques for Tuna With Pole and Line

"Tuna Fishing With Pole and Line," edited by M. Ben-Yami, has been published by Fishing News Books Ltd. for the Food and Agriculture Organization (FAO). The author is with FAO's Fishery Industry Division.

The book contains nine parts: Introduction (with historical notes, data on new fishing grounds, live bait, and fishery development), main species fished, vessels, crews, live-bait techniques, handling and transporting live bait, fishing gear and auxiliary equipment, fishing operations, and handling fish on board. Additionally, a world guide to baitfish for pole and line fishing is given.

The manual is aimed at smaller-scale operations and provides information and advice to newcomers to pole-and-line fishing as well as for those who might want to improve or alter their present techniques. It is based in large part on a Japanese manuscript, but contains data on fishing variations and vessels from Polynesia, Sri Lanka, Hawaii, and other areas and nations.

Species discussed include skipjack tuna, albacore, frigate mackerels, bonitos, and little tunas. Fishing techniques covered include a wide variety of nets: Beach and boat seines, lampara nets, purse seines and ringnets, chiromila nets, drive-in nets, stick-held dipnets, blanket nets, Hawaiian liftnets, opelu nets, Lakshadweep bait fish nets, Sri Lanka liftnets, and others. Use of lights and bait is also discussed. Other gear mentioned includes single and double hooks and jigs or lures (Japanese and Pacific Island feather jigs and pear-shell lures), and trolling jigs. Lines, poles, and other auxiliary equipment (i.e., handnets and scoopnets, chum tanks and buckets, body protection gear, etc.) are detailed.

Also covered are selection of fishing grounds, searching for tuna, and capture operations. Many useful illustrations of the vessels, nets, and other gear and techniques enhance the text, and the book will be useful as a basic guide to this type of fishing.

The 150-page paperbound volume is available from Fishing News Books Ltd., 1 Long Garden Walk, Farnham, Surrey, England for £6.50 plus 65p postage.

Limited Entry: The Conference Proceedings

Publication of "**Limited Entry As a Fishery Management Tool,**" edited by R. Bruce Rettig and Jay J. C. Ginter, has been announced by the University of Washington Press, Seattle. The Washington Sea Grant publication presents the proceedings of a July 1978 national conference on limited entry held in Denver, Colo.

The issues are addressed from biological, economic, legal, political, and anthropological viewpoints. Other papers review the limited entry experience in Alaska, Washington, Michigan, Wisconsin, Canada, and Australia. Counterpoints are brought out in published questions and answers.

While the concept of limited entry is controversial, this new volume takes a step toward addressing the question of whether limited entry is a practical and effective management tool. The 463-page paperbound volume is available from the University of Washington Press, Seattle, WA 98105 for $15.00.

A Symposium on Fish Phenology

"**Fish Phenology, Anabolic Adaptiveness in Teleosts,**" edited by P. J. Miller, has been published by Academic Press (London) as Number 44 of the Symposia of the Zoological Society of London.

The book addresses a new definition of phenology, relates it to anabolism, and explores it in teleost fishes. Basic topics include treatment of energy partitioning, accumulation, endocrine control, and response to environmental influences. Timing, magnitude, and fecundity of reproductive commitment is discussed for some ecotypes, and a wide range of habitats from savannah pools to the deep sea are considered, as well as phenological modifications required by the migratory life-style of salmonids, seasonality in tropical habitats, and the diminutive adult size of certain aquarium fishes. Also addressed is the nature of senescence affecting the duration of individual anabolism and the genetic transmission of growth and reproductive characteristics.

The 450-page volume will be of interest to both fisheries biologists and researchers. The book is available from the publisher, Academic Press Inc. (London) Ltd., 24-28 Oval Road, London NW1 7DX, England for $52.

The Fishes of New York and Idaho

Two new state guidebooks to fishes, including commercially and recreationally valuable and anadromous species, have been published at opposite ends of the country. "**Freshwater Fishes of New York State, A Field Guide,**" by Robert G. Werner, funded in part by a NOAA grant, was published by the Syracuse University Press. The author is Professor of Forest Zoology at State University of New York College of Environmental Science and Forestry at Syracuse.

A key to all New York fishes is given along with more complete data on the identification, biology, life history, and distribution of 68 of the most common species. A table shows the distribution of each species by major drainage basin. In addition, selected references provide suggestions for additional information on the various species. And, a basic guide to fish anatomy and a glossary is provided.

Families included in the book are: Petromyzontidae, Acipenseridae, Lepisosteidae, Amiidae, Clupeidae, Hiodontidae, Salmonidae, Osmeridae, Esocidae, Umbridae, Cyprinidae, Catostomidae, Ictaluridae, Aphredoderidae, Percopsidae, Gadidae, Cyprinodontidae, Atherinidae, Gasterosteidae, Cottidae, Percichthyidae, Centrarchidae, Percidae, and Sciaenidae.

The volume vastly updates a 1903 volume "A Catalog of New York Fishes" by T. H. Bean, but would have been of more value with more and better illustrations. It remains useful, of course, as a current listing of and key to New York fishes.

Published in both paper ($11.95) and cloth ($20) editions, the book is available from Syracuse University Press, 1011 East Water Street, Syracuse, NY 13210.

"**Fishes of Idaho,**" by James Simpson and Richard Wallace, has been published as part of the Northwest Naturalist series by the University Press of Idaho. Simpson, retired, was Chief of Fisheries, Idaho Department of Fish and Game, and Wallace is with the Department of Biological Sciences, University of Idaho.

This book represents the first attempt to publish distributional and life history data on all Idaho fishes and is an outgrowth of an earlier key to Idaho fishes by the senior author in 1962. In all, 34 genera representing 13 families are included. Information is given on 67 species (39 native, 28 introduced) believed to have reproducing populations within the state (seven questionable species are also listed).

An illustrated key leads to the individual species accounts which include data on the identification, biology, and life history of the species, its natural and Idaho ranges, and on its uses or value. The book is amply illustrated with black and white drawings.

Information is given on past collections and accounts of Idaho fishes, river drainages, lakes, and reservoirs. A provisional checklist of Idaho fishes is also provided. Appendix one presents a glossary and Appendix two lists Idaho fishes by drainage. A list of references is given for further reading.

Families discussed include Petromyzontidae, Acipenseridae, Salmonidae, Esocidae, Cyprinidae, Catostomidae, Ictaluridae, Percopsidae, Gadidae, Poeciliidae, Centrarchidae, Percidae, and Cottidae.

Written for both the professional biologist as well as the interested layman, the volume fills a definite void and will be useful to both audiences. Indexed, the 237-page paperbound volume is sold by the publisher, University Press of Idaho, P.O. Box 3368, University Station, Moscow, ID 83843 for $6.50.

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 6, "A List of Common and Scientific Names of Fishes from the United States and Canada," third edition, 1970. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Citations

Title the list of references "Literature Citations" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10- inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., BIN C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 100 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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